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ACOUSTICAL CORRECTION

·Johns-Manville·

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ACOUSTICAL CORRECTION

How correct acoustical values can be provided for in every room in which good hearing conditions are necessary

JOHNS-MANVILLE
JM
PRODUCTS

The Johns-Manville System of Sound Control

WHY LET THEM STRAIN THEIR EARS—AND THEIR NERVES?

Faulty acoustical conditions in a room make hearing difficult. Intense concentration is necessary. This taxes not only the ears but the whole nervous system. A student under such conditions soon develops a chronic case of inattention, at the cost of complete education. He becomes tired of straining to hear and gives up. This grows in the habit of inattention. But faulty hearing conditions need not be tolerated in any room whether it is in a school, a church, a theatre, a concert hall, an auditorium, a court room, or in any other place intended for speech and music. This book tells the story of how easily and simply you can have ideal hearing conditions

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Faulty hearing conditions need be tolerated *no longer*

GOOD hearing conditions are as important today as good architectural design and good construction. Every auditorium, church, theatre, concert hall, court room—in fact every room that is used for speech or music—should have good acoustics so that every listener can hear and understand clearly and distinctly.

Yet how many times have you had to experience the discomfort of *not* understanding the speaker, or of trying to listen to music that was distorted or noisy, or that seemed "to go bass."

Sitting in a pew in the first rows of a church, you could hear comfortably. But when you were forced to take a pew in the 10th row, or the 15th, or one near the wall, you found you could *not* understand everything. Maybe you couldn't understand anything. Yet you paid the closest attention. The music seemed unnatural, or rumbly, or distorted. Or an echo bothered you and made hearing difficult.

Bad acoustics puts a strain on the nervous system

Trying to hear in a room where it is difficult to understand, requires intense concentration. Not only are your ears taxed in their effort to hear but every muscle is under a tense strain. Surplus energy is used up. There is no opportunity to relax, and without relaxation complete enjoyment is unobtainable. If you seemed tired after a speech or lecture, or an evening at the theatre, it is because you had to work — and work hard—for your evening's entertainment.

The speaker and the musicians are also under a strain in a room with faulty acoustics. They have to use extra effort to make themselves understood and appreciated. Naturalness of speech and music is forsaken in their forced effort to be heard. And after the performance is over they are often tired out from the strain of trying to "put it over."

Such faulty acoustical conditions exist not only in churches and theatres, but also in music and banquet halls, in ball rooms, in court rooms, lecture rooms and auditoriums. Probably they are present in the buildings in which you are interested — irritating to the audience, often driving them away—never to return.

These benefits can be yours, too

But faulty hearing conditions need no longer be tolerated. Since 1911, Johns-Manville has been applying scientific corrective measures to rooms of the auditorium type. Ideal hearing conditions have been provided in thousands of churches, public auditoriums, concert halls, school class and lecture rooms and auditoriums, court rooms, banquet halls, ball rooms, and theatres (both legitimate and "talking picture"). In these corrected rooms, it is a real pleasure to listen to a speech, a sermon, a play or a concert, for every listener can hear easily and comfortably no matter in what part of the auditorium he may have to sit.

You, too, can have correct acoustics—ideal hearing conditions—in any room in which you have an interest—like thousands of other building owners and managers, who now know the benefits and advantages that the Johns-Manville System of Sound Control brings.

On page 13 you will find the story of a church congregation that suffered with bad acoustics for 50 years. Then they came to Johns-Manville. The story of how a theatre, after it was corrected, attracted capacity crowds, is told on page 10.

But before you turn to these, we suggest you read this book from the beginning to end. You will find in these pages an interesting story of the various acoustical defects that cause the trouble, what they are, and how they can be corrected, easily and successfully, to provide ideal hearing conditions.

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What causes acoustical troubles?

TO understand how ideal hearing conditions can be provided, we must first understand sound—what it is, how it travels, its action in buildings and in what way the size, shape and construction of our buildings affect the sounds produced within them. Then we will readily see how simple it is to apply corrective measures to any room of the auditorium type—an old one or a new one in the planning stage.

What sound is and how it behaves

Sound, like heat, light and electricity, is a form of energy. It is produced by a vibrating body, such as a bell, a musical instrument, or a person's vocal chords, or a countless number of other things; and it spreads outward from its source in a series of ever-expanding spherical waves. This is in much the same way that ripples of water travel when a stone is thrown into a pond or pool of water. Only ripples roll out in an ever-expanding circle until they reach the shore or die on the way, while sound waves spread up and down as well as outward in every direction, like a giant soap bubble.

The speed at which sound waves travel in air at room temperatures is 1120 feet per second, or in other words 763.2 miles per hour. About as fast as a bullet fired from a rifle. When produced out-of-doors, in an open field in the country, these waves will soon pass on into atmosphere. In a room, however, the four walls, ceiling and floor check their outward movement and reflect the waves back into the room. These reflections continue from ceiling to walls, to floor, to ceiling, back and forth and across the room, until all the sound energy is completely dissipated. This is due to the fact that the hard-surface materials used as interior finishes are poor absorbers of sound.

The source of acoustical troubles

It is this multiple reflection of sound which is the source of the most common form of acoustical trouble—reverberation, or the continued

EFFECTS OF MULTIPLE REFLECTION OF SOUND WAVES

Light and sound waves are reflected in a similar way. Recognizing this fact, Johns-Manville engineers can study the sound conditions in an auditorium by photographing light to simulate sound. In this picture of a longitudinal cross-section of an auditorium model, concentration of sound in the upper part and rear of the auditorium is shown, caused by the multiple reflections from the ceiling surfaces

prolongation of sound after the original sound has stopped.

Every one of us when we were children discovered this phenomenon of reverberation. We may have heard it when we shouted into a well or a cistern or down a manhole (if we were city-bred). Or perhaps we noticed how delightfully loud our footsteps and our cries became when we pried our way into an empty house. In each case the sound seemed to travel on, and on, and on. We could hear it for quite a long time as it gradually distorted itself more and more and died away.

REVERBERATION—AS THE PHOTOGRAPHER VISUALIZES IT

Reverberation makes a sound seem to travel on, and on, and on. When only one sound is made, the prolongation causes no confusion. But when several sounds are produced, or several words spoken, each sound will overlap the preceding one, blurring it. As pictured by a photographer, this is similar to the condition created by several people talking at the same time

One of the best analogies of reverberation is a water bucket pierced with a number of holes up and down the sides, with a stream of water running into it. The bucket will fill up until as much water is running out of the holes as is coming in from the faucet. It will then hold a steady level until the faucet is turned off, when the water will run out, first rapidly, then more and more slowly, until it is all gone.

In this analogy, the bucket represents the room. The stream of water from the faucet represents the sound energy and the holes in the bucket, the sound absorptive power of the walls. As the sound source is turned on, the sound energy spreads out in rapidly moving waves and within a very small fraction of a second fills the entire room. It is then reflected time after time. As new sounds are produced, each succeeding wave will add more energy until a certain energy level fills the room. How high this level will rise depends on how rapidly the sound is absorbed by the walls, just as in the water bucket the level depended on the amount that ran out the holes.

When the sound source is turned off, the level falls, rapidly at first, then more slowly until only a few scattered waves are left unabsorbed. Finally these disappear. It is obvious that the sounds will be audible long after the source has ceased, and that the time of duration of audibility will be dependent on how rapidly the walls take up what sound is left.

Effects of reverberation

The time during which a sound remains audible after the source has been shut off varies in length of duration with the volume of sound, the size of the room, and the rapidity of sound absorption. The greater the volume of sound, the more energy there is to be absorbed before the sound is inaudible. The larger the room, the greater is the distance between each reflection and the longer is the period of prolongation. An interior finish which absorbs a

comparatively small amount of sound energy will prolong sound longer than one that has a high absorption. This period of reverberation ranges from a small fraction of a second to as high as 5 or 6 seconds, and even longer.

With a speaker uttering on an average of 5 syllables per second, there will be 15 syllables, or distinct sounds, at any one instant in a room where a sound is prolonged for 3 seconds after it is spoken. With additional syllables following at the same rate of production, it is obvious that this prolongation will become annoying. Each successive word or syllable will overlap the preceding ones and cause blurring and confusion. Hearing under such conditions will be difficult, sometimes impossible. In a more reverberant room, this condition will be even more aggravating.

This is true, too, of music. Although more overlapping may be tolerated in the case of music than speech, yet, excessive reverberation will prolong all notes too long and the melody will be utterly confused and blurred.

Reverberation may occur in any room larger than a closet, regardless of whether it be round or square, high ceilinged or low ceilinged, or whether it be built of wood, plaster, or marble. Fully half the theatres built suffer from the effects of reverberation, and in public auditoriums, lecture halls, churches, and the like, the percentage is much higher. That is why corrective measures are being applied every day by Johns-Manville in all types of buildings.

Loudness should be distributed uniformly

Another acoustical defect which may be encountered in auditoriums of every kind, is that of unequal loudness distribution, which means that there is not enough sound energy in certain areas of the room and too much in other areas.

When first man began to make speeches, his audience was small and his voice carried without effort to all listeners. No problem of loudness distribution existed then. However, as the numbers increased, it was found that those in the rear could not hear. The sound energy directed at the audience was quickly absorbed by the clothing of the listeners while the upper part of the sound waves passed over the heads of the audience and escaped unused. By raising the speaker on a platform (or a soap-box if there were any) above the level of the audience, more of the sound energy was thrown on the audience, thus carrying it farther back.

Developments in the distribution of sound

The next step in the development of loudness distribution was the raising of the rear seats, to bring them in line with the upper part of the spherical sound waves. Later a wall was built behind the speaker. The rear portion of the sound waves were reflected from this wall back into the audience. These reflected waves reached the audience but a small fraction of a second after the direct wave, increasing their loudness and making it possible to hear them at a greater distance.

Still only part of the speaker's efforts served the audience, as all the sound rising upward was lost through the open space. But by placing a roof and four walls around the speaker, all of the sound energy produced was confined in the auditorium. The average loudness of the sound throughout the room was greatly increased. And this loudness was nearly equalized at the front and rear.

As the audiences grew in size, galleries or balconies were built to bring the distant part of the audience nearer to the front (or the source of the sound). However, balconies and other special shapes such as recessed or extremely long and narrow rooms, deep beamed ceilings, etc., tend to overcome the value of this increase in loudness, by building up the reflections and causing extreme loudness in certain sections while other places lack loudness.

Small rooms of regular shape are seldom troubled with loudness distribution, but large auditoriums, churches, theatres, etc., especially those of intricate design, very often are affected. For example, beneath the balcony or along the side aisles, it is often difficult to hear a speaker because of inadequate loudness.

These conditions can be guarded against by properly arranging absorbent or reflecting sur-

faces. This can be done in the plan stage of design before the building is erected or in a building now existing. When acoustical materials are employed to correct other defects such as reverberation, they should be located with a view to obtaining uniform loudness distribution.

Sound boards have been used to throw the speaker's voice to the rear of the house. But if they are used, it is important that they be quite large to be efficient. Ugly sounding boards or speaker baffles are not required and seldom used today. Controlled reverberation has been found sufficient in the correction of loudness distribution.

Mechanical speakers, too, are often used to increase the volume of sound and carry it to every part of the house. But, such speakers usually increase the reverberation already present in a room.

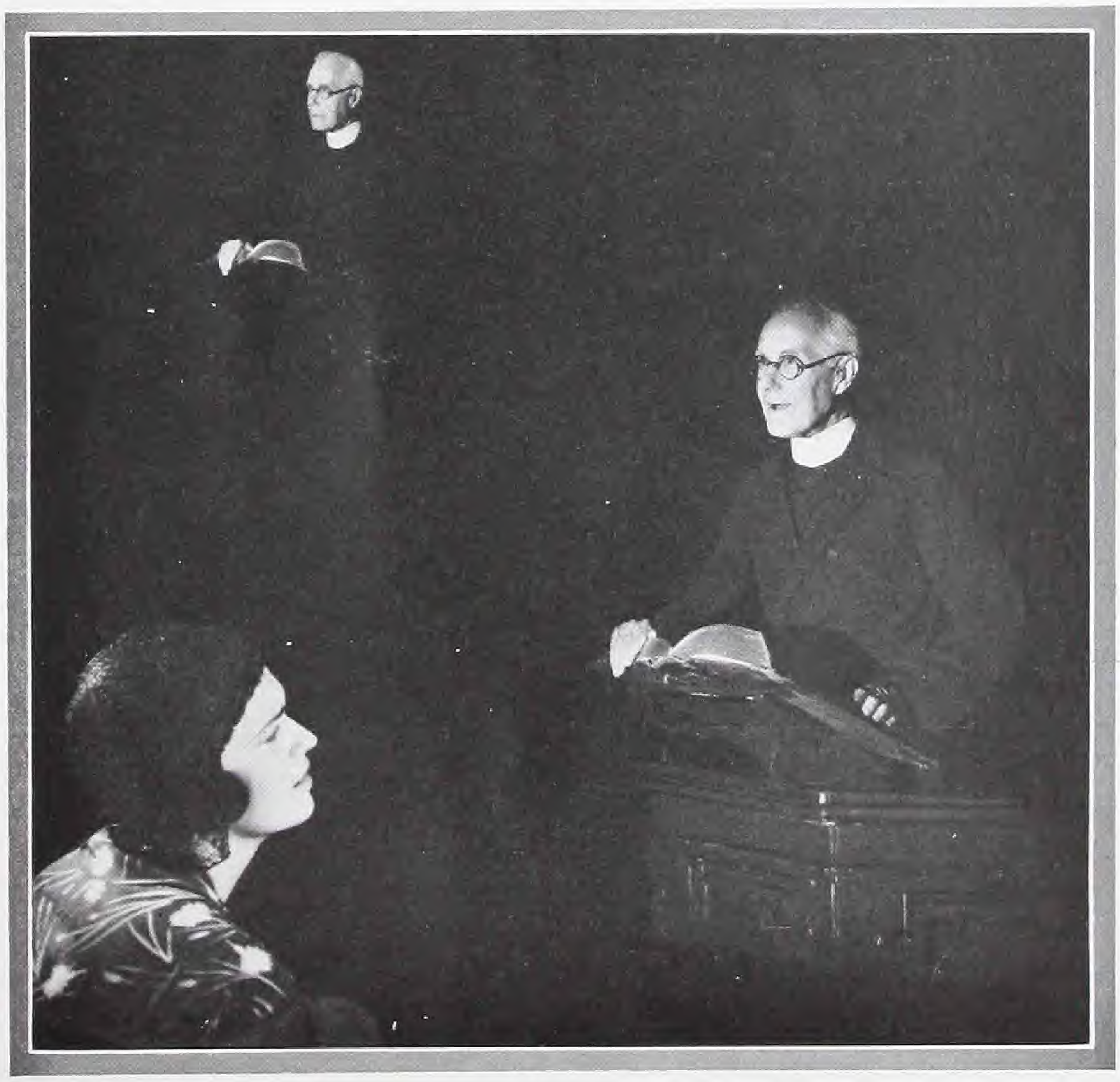
As we have seen, reverberation is sometimes needed for better distribution of loudness, but it has a tendency to cause trouble as soon as it becomes excessive. Therefore, reverberation must be controlled. This is accomplished by absorbing excessive reverberation. Since the interior finishes are poor absorbers of sound, it becomes necessary that materials which are far better sound absorbers be installed.

It is because of this necessity for better sound absorbers that Johns-Manville Acoustical Treatments were developed. There are several J-M Treatments and each one is a sound absorber. These materials have been used to successfully solve thousands of acoustical problems.

Echo is not reverberation

Often reverberation is called erroneously by the term "echo." But the distinction is clear. Reverberation is the continued prolongation of a sound after the original has stopped. An echo is a *distinct* repetition of a sound which is caused by a very strong reflected wave that reaches the ear after an appreciable time interval has elapsed since the original sound was heard. The reflected wave has had to travel a longer distance than the direct sound and so reaches the ear at a later time, giving the effect of repetition. Echoes in interiors are usually caused by curved surfaces such as domes, vaults, coves, pendentives and warped areas.

Sometimes the reflected waves reach the ear before the original sound has passed. This



AN ECHO IS A DISTINCT REPETITION OF A SOUND

Sometimes a reflected sound wave reaches the ear after long enough time has elapsed since the original sound was heard, so that it appears to be a duplicate sound coming from another place—just as if a second person made the same sound a short time after the first person had finished

(Photos courtesy of Philco)

MUSIC IS DISTORTED BY POOR ACOUSTICS

Distortion of music is similar to distortion of pictures, or to the distortion of your image as you gaze in a trick mirror. Certain parts are over-emphasized and other parts restrained, causing an unreal picture. In the same way, distortion of music is caused by the over-emphasis of overtones while the fundamental notes are subdued, throwing the music out of balance

causes the sound to become momentarily confused or blurred and hearing is made difficult. So-called "dead spots," in the great majority, are the result of echo.

All types of echoes are local in character—usually confined to a few seats, or a few rows in some particular part of the auditorium. They can be eliminated either by a slight change in design or by the application of an absorbing material, or both. Change in design is not often desirable, sometimes out of question. Therefore, correction is generally made by installing the proper amount of sound absorbent material on the reflecting surface.

How the quality of sound is changed

Two forms of acoustical defects which change the quality of sound and which affect music more than speech are "resonance" and "distortion."

By resonance is meant the sympathetic vibration of a wall panel, or a body of air within a room in response to a note of some definite pitch.

This vibrating body magnifies the intensity of *that* note so that it becomes more prominent, or louder, than all other tones. When a complex sound is produced, some notes are reinforced by resonance, some are not. Thus the quality of the sound is changed. The result is an unbalanced effect on musical values.

Resonance is frequently encountered in organ chambers, and sometimes in auditoriums themselves. But in general it is not very common.

Occasionally music reaches our ears distorted. Overtones may be more prominent than the fundamental notes. At times, the low tones seem to rumble or the high ones are harsh or shrill. Such distortions change the quality of music and throw musical values out of balance, whether it is an auditorium, theatre, church, broadcasting studio or concert hall.

This is true, too, of radio reception rooms. Poor acoustics will distort the music from a radio set placed in the room.

Radio engineers, having conquered most of the acoustical problems in the engineering of the sets themselves, and realizing that listeners may be losing the clear, life-like tones of which the sets are capable, are more and more turning their attention to acoustical properties of the rooms in which their sets are placed.

Walter E. Holland, vice-president of Philco, one of the largest manufacturers of radios, and formerly chairman of the engineering committee of the Radio Manufacturers' Association, has consistently pointed out the necessity of correct room acoustics for best reception. In writing to Johns-Manville recently, he said:

"The position of a radio receiver in a room often affects its tone quality. It should be placed so that, when they reach the listener, the tones reflected by the walls do not interfere with those coming directly from the loud speaker. The best radio built will not give the perfect reproduction it is intended to give if the room is not acoustically corrected to prevent distortion."

Distortion is chiefly the result of non-uniform absorption. A great many materials are highly efficient sound absorbers at certain frequencies and very inefficient at other frequencies. In most cases, the higher frequencies are the ones absorbed. This results in a building up of the lower register so that voices and music sound lower and heavier in character.

The remedy here lies in the use of a material which has uniform absorption at all frequencies—of low and high notes as well as those in the middle register. Here again, J-M Acoustical Materials stand far in the lead.

Extraneous sounds interfere with hearing

In addition to these acoustical defects, there is still the problem of extraneous sounds to be dealt with before hearing conditions can be made ideal. Sounds from shuffling feet, coughing, sneezing, whirring electric fans, laughter and gaiety of the throngs outside. A street car rumbling by. The scream of fire engines. The roar of automobiles and trucks. What a confusion of sounds these add to the multitude of sounds already present in an acoustically imperfect room. These sounds must be taken into consideration before corrective measures are applied.

Every acoustical defect can be remedied

Wherever people gather indoors for entertainment, education, or worship, the problem of hearing conditions or room acoustics arises. Occasionally the problem is brought about by the presence of all forms of acoustical defects. At other times, by only one or two.

But no matter what the defect, nor how complex the problem, Johns-Manville can apply the needed corrective measures.

Echoes can be eliminated. Resonance and distortion remedied. Reverberation can be corrected and made ideal in any room, no matter if it is used for speech or music, or both, or what size audience is present.

In this work, Johns-Manville is a recognized leader. This is evidenced by the growing number of architects, builders and building owners, who are turning to Johns-Manville for the solution of their acoustical problems, and by the countless number of buildings which have been acoustically corrected and the growing number that are receiving corrective treatment every day. The photographs in this book will give you an idea of the variety of rooms which need acoustical correction—places where faulty hearing conditions can be corrected with the proper Johns-Manville Acoustical Treatment.

On the following pages are two typical examples of how corrective measures have been successfully applied by Johns-Manville. These are but two of the thousands of buildings which have been corrected by Johns-Manville. A few of the other places, where ideal hearing conditions have been provided by the proper application of the correct Johns-Manville Acoustical Treatment, are listed on pages 15 to 22. All of these installations prove it pays to have correct acoustics.

From the above photograph you can get an idea of the size of the Howard Theatre. Note how the panels of J-M Sanacoustic Tile were applied to the walls to correct the faulty acoustics in this auditorium

Capacity crowds are attracted to *acoustically correct* theatre

EVERYBODY knew that the acoustics of the Howard Theatre, Chicago, Illinois, was bad. The theatregoers knew it. The manager knew it. The organist knew it. Even the ushers knew it. During almost every performance, the orchestra floor was mottled with areas of empty seats—empty because people knew from sad experience that in those seats they just could not hear anything.

This theatre was built for silent motion pictures. No requirements for good hearing conditions existed when it was erected. But with the advent of sound movies, the acoustics in the theatre was found to be faulty—so much so that it was practically impossible to reproduce "talking" pictures successfully.

Even the finest super productions sounded blurred and confused, and in certain areas you could not tell whether the sound was coming from the loud speakers or from some point in the rear of the house. All the voices were distorted, lacking something of their natural mellowness and richness. They seemed gutteral and low.

The firm who had installed the sound equipment had returned time and again, making minor adjustments here and there in the futile hope of improving matters, but each time they had reiterated their first diagnosis—"it's the acoustics of the theatre."

The worst of it was that the box office receipts began to show the effect. The shows

were just as good as those of other theatres in the vicinity. The theatre was as attractive. The service was just as satisfactory. But the fact remained that the pictures were not pulling the crowds they should.

It all seemed very mysterious. Why should it be impossible to hear in the eighteenth row, when you could hear in the twelfth or in the twenty-fourth? Why should organ music sound all right, when a man singing sounded as if he had the proverbial hot potato in his mouth? And above all, *what* was to be done about it?

How this problem was corrected

J-M acoustical engineers were called in to study the conditions and make their recommendations.

The theatre plans and all available data were assembled—the shape of the house, the type of seats, the size of the audience, the type of sound reproducing equipment, etc. A careful analysis was made, the theatre being checked for one possible defect after another, until the list had been exhausted.

First—there was too much reverberation. That accounted for the confusion and blurring. Even down in front hearing conditions were none too good.

The analysis showed too many highly reflective surfaces — not enough absorption. Each sound was reflected again and again—from this wall and from that—until it was prolonged for a period of 5.3 seconds' duration when the theatre was empty and 2.1 seconds at full capacity. This was far beyond all permissible limits.

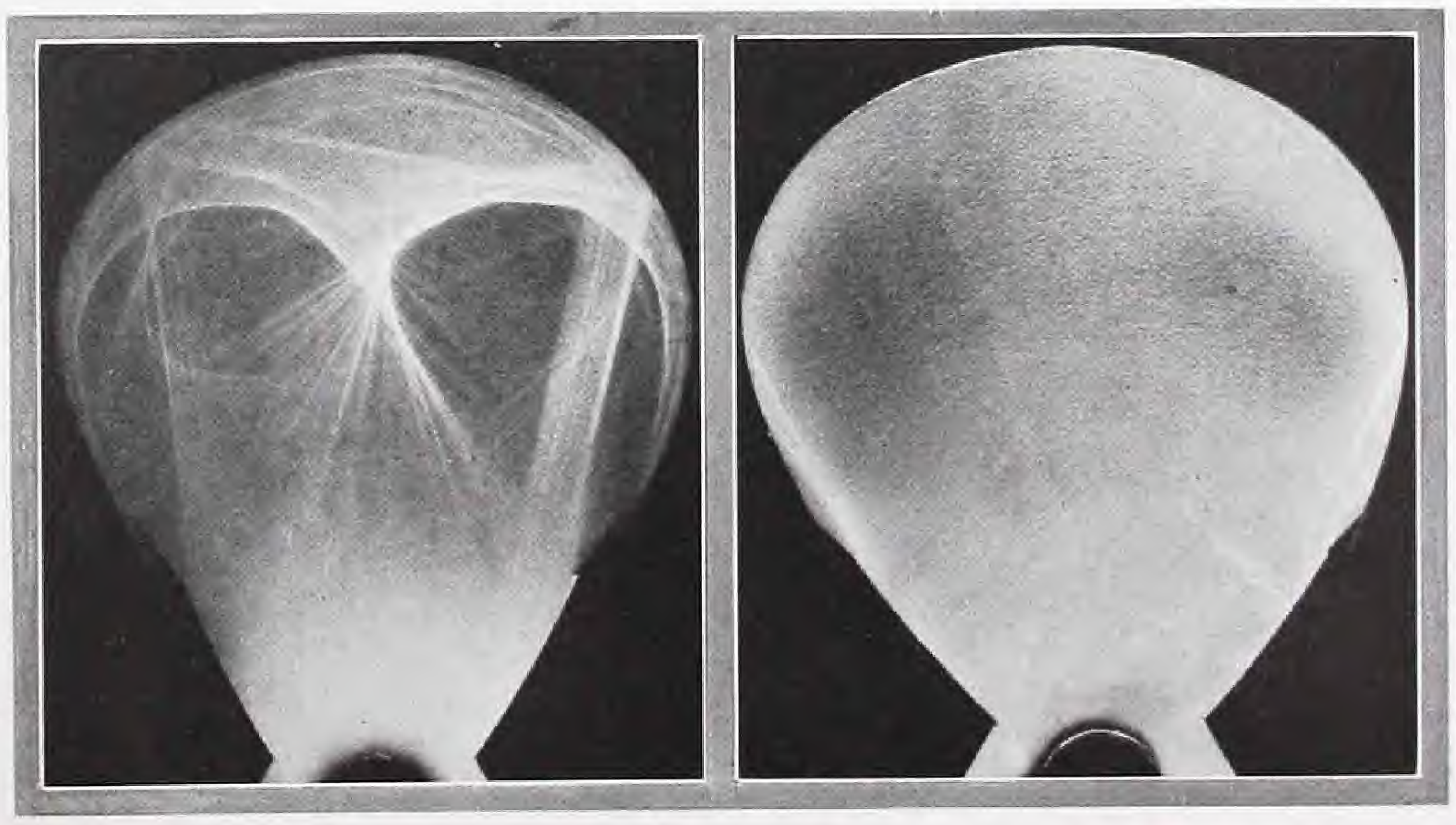
Second—the curved walls—the Howard theatre is semi-circular in design—brought the reflected sound waves to a focus in the body of the house, creating an echo at those points. This accounted for those inexplicable areas where customers just could not hear. The echo was only audible in certain areas, but at those points the reflected sound from the walls was so pronounced that it seemed the sound came from that direction.

Lack of low-frequency absorption caused the notes of higher frequency to be absorbed more readily than the low notes. This made the voices seem guttural, and sound boomy.

Once the diagnosis was complete, Johns-Manville acoustical engineers found the correction of these defects to be very simple. Approximately 3,900 square feet of J-M Sanacoustic Tile, a material high in sound absorptive qualities, was installed in vertical panels on the walls. Double pads of this sound absorbent were installed in every other panel. This broke up the tendency for concentration of reflected sounds. It also afforded absorption for sounds of low frequency and provided an even distribution of music in its natural tones.

The period of reverberation was reduced to 3 seconds' duration when the house was empty and 1.6 seconds with a capacity audience. Sounds are no longer prolonged long enough to become disturbing. Echoes have been eliminated. Now all seats in the house are equally good from an acoustical standpoint.

And best of all—the house is now "packed"—at the expense of neighborhood competition.



BEFORE TREATMENT AFTER TREATMENT

(Left) Before correction, sound was unevenly distributed. An echo was heard where sound waves are brought to a focus in the center rear, with comparatively quiet spots to the either side of that point. (Right) After corrective measures were applied, sound was evenly distributed throughout the theatre, and echoes were eliminated

"ACOUSTICS ARE ALL THAT COULD BE DESIRED"

Wm. H. Dechant & Sons, Architects, have re-decorated the St. Paul's Memorial Reformed Church into a very beautiful church. The design on the ceiling was applied right on the J-M Acoustical Treatment used to correct the faulty hearing conditions existent in this auditorium, resulting in an attractive, and at the same time an acoustically correct church. Your church, too, can be corrected—and still be beautiful—whether it is large or small, with a capacity for thousands or more, or for only a hundred

After 50 years of faulty acoustics church *is corrected* the J-M way

CHURCHES present acoustical problems that are generally highly complicated. They must be adapted to speaking and reading, and to organ and vocal music. Unless the acoustics are correct, hearing conditions may be not only bad but often unbearable.

One of the hundreds of churches which had faulty acoustics until corrected by Johns-Manville, is the St. Paul's Memorial Reformed Church, Reading, Pa.

This church was built in 1873. For over fifty years the congregation had sought a remedy for the very bad acoustical conditions which existed in the church auditorium. They tried almost every device and method of correction which was recommended. None proved satisfactory.

Two years ago, the auditorium was to be renovated and remodeled. Wm. H. Dechant & Sons, the present architects for the church, recommended the Johns-Manville method of acoustical correction as the solution to this acoustical problem. Members of the congregation were at first very skeptical, especially the older ones who had witnessed the failure of so many previous attempts. But the official body of the church was eager to have correct acoustical conditions in the auditorium and the architects were given permission to consult the Johns-Manville acoustical engineers.

First, an acoustical analysis was made by the J-M engineers. This showed the church was too reverberant. Sounds were prolonged for a period of 2.6 seconds with every pew occupied. With only 200 members of the congregation present, the period of reverberation was 3.5 seconds. With a speaker averaging 5 syllables per second, there were from 13 to 18 separate sounds in the auditorium at one time, causing an acoustical condition that was very distressing. Each word ran into the preceding one, blurring it. By the time five or six words were present in the air at the same time, parts of the sermon would become ambiguous and unintelligible.

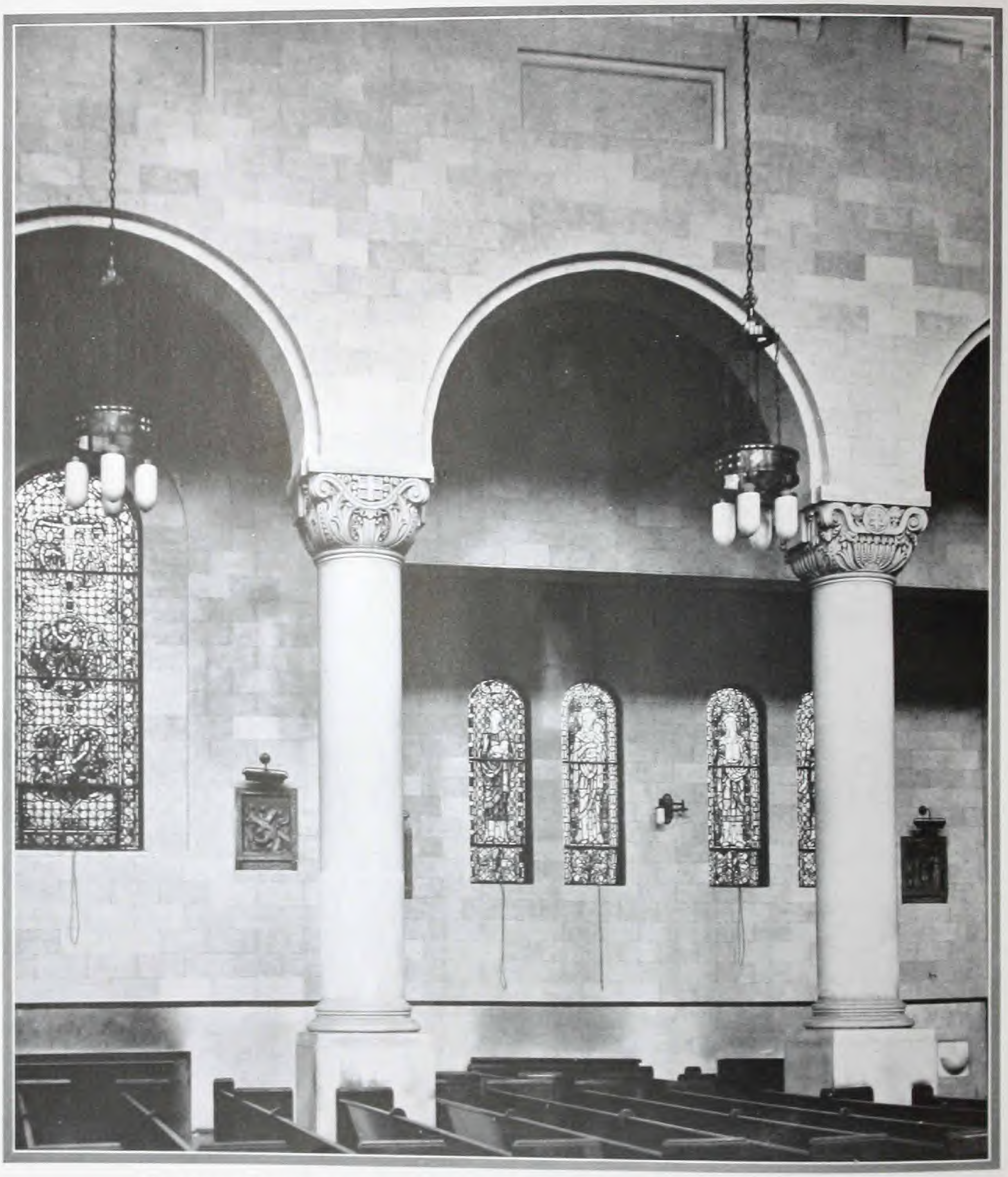
Organ and choir music also was affected by the excessive reverberation. All tones were prolonged. Some notes were reinforced and others were subdued, distorting the quality of the music.

"Entirely satisfactory to us"

To correct the acoustical defects in this church, J-M Nashkote was used. This acoustical treatment was installed on the ceilings, reducing the period of reverberation to 1.57 seconds with a capacity congregation and to 1.8 seconds when only 300 worshippers are present. The results were immediately so satisfactory that the Rev. Charles E. Creitz, Pastor of the St. Paul's Memorial Reformed Church, wrote the following letter:

> "It gives me great pleasure to testify to the complete satisfaction with which you handled the acoustical problem of our Church. For more than fifty years the congregation sought periodically to remedy a very bad acoustical situation existent from the erection of the building in 1873. Almost every new device recommended was tried, but all to no avail. With the renovation and remodeling of the auditorium, our architects recommended your company to deal with the problem. Their suggestion was treated with a good deal of skepticism, especially by the older members, but our official body was willing to make one more trial and the outcome is entirely satisfactory to us. The acoustics are now *all that could be desired*, and we are grateful for the relief that you brought."

The St. Paul's Memorial Church is only one of the thousands of churches in which a Johns-Manville Acoustical Treatment is controlling sound and providing ideal hearing conditions.



AN INTERESTING DECORATIVE FINISH PLUS CORRECT ACOUSTICS

In the St. Anselm's Roman Catholic Church, at Swissvale, Pennsylvania, J-M Rockoustile was chosen as the acoustical treatment because of its high coefficient of absorption and its interesting stone-like texture. Installed on the walls, side aisle ceilings and the arches, it blends perfectly with the design and interior decoration of this church. Besides, this material has corrected the "disagreeable conditions which have annoyed the Parish for five years." J-M Rockoustile is but one of the number of J-M acoustical materials developed to meet the variety of acoustical problems and decorative requirements

The new Studio "L," of the National Broadcasting Company, New York City (shown above), is another example of how J-M acoustical engineers have met the problem of the interior decorator with a highly absorptive acoustical material. In this studio, Fortuny Rep, an imported French drapery fabric, was cemented to J-M Sanacoustic Tile, helping to give the studio a home-like atmosphere and at the same time correct acoustical value. Here Phil Cooke can be seen seated at the mike

There's a J-M Treatment to meet *every* acoustical problem

NO one sound-absorbing material can possibly serve as a "cure-all" for every acoustical problem. There are too many conditions to be taken into consideration—too many requirements to be met.

Each acoustical defect offers an individual problem. The presence of more than one defect brings about a problem of complexity which increases as the number of defects present increase. A small auditorium presents a different problem from a large one. As the size of the audience varies, the problems again vary. In order to remedy so many different problems and meet the different conditions there must be available a variety of materials with varying sound-absorptive qualities.

Then, too, such materials must harmonize with any architectural design, or be capable of receiving such finishes as will bring them into harmony with the interior decorative scheme.

It is because of these reasons that Johns-Manville has developed a great number of acoustical materials, each with a different coefficient of absorption. Each comes in a different finish. Or they can be covered with a variety of finishes without impairing their absorptive qualities.

A special department, the J-M Architectural Service Department, has worked with the J-M engineers in the perfection of these materials so that they meet every interior decorative requirement. In addition, the members of this Architectural Service Department, many of whom are licensed architects, will be glad to

ADAPTABLE
TO ANY DESIGN

This is one of the decorative effects in which J-M Sanacoustic Tile is available from the factory—an Italian Renaissance coffered ceiling in a beautiful green and gold. But the Standard J-M Sanacoustic Tile is such that any design can be painted on it without affecting its sound-absorbing qualities

work with you and the acoustical engineers in the selection of the proper material in reference to decorative possibilities.

Plaster or stone effects—herring-bone or tile designs—and decorative paintings no matter how intricate the design—are all possible with J-M treatments.

In other words, from the group of J-M Acoustical Treatments described on pages 17 to 22, J-M Acoustical engineers can make an unbiased selection of *the* material which is best fitted to meet the particular conditions of each individual problem.

The solution starts with an analysis

But, before any choice of material can be made, each auditorium must be carefully studied and an analysis made of its acoustical conditions. This is the first step taken by J-M engineers. Just like a doctor first makes a diagnosis of a case to locate the cause of trouble, before he ventures to prescribe the remedy.

Included in a J-M acoustical analysis are such studies and recommendations as follows:

The amount of reverberation present is studied. The amount of correction needed to provide ideal acoustics for speech or music, or both, and the area of treatment necessary are specified.

A careful search for echoes, resonant bodies, distortion and other local defects, with recommendations for area and placement of corrective treatment, is made.

A study is made of the sound sources used—their power, distribution, characteristics.

Recommendations for the elimination of extraneous noise of all kinds are made.

The problem of loudness distribution is

This close-up of a ceiling of J-M Rockoustile shows its interesting variegated texture and stone-like effect. With this material ceiling patterns are easily worked out to suit individual preferences

studied and recommendations for any required correction are offered.

One or more of the suitable Johns-Manville Acoustical Treatments are selected and the area and amount of installation are specified. This selection of materials is made with the greatest care, the various factors of appearance, sound absorption, cost and permanence being considered.

It is in the proper selection and application of these materials after the defects have been located, that Johns-Manville is prepared to offer you a positive solution to the acoustical problems present in any room used for speech and music, no matter how old the building is.

If the building is in the plan stage, the problem of hearing conditions should be taken into consideration. Acoustical correction is now an exact science, and proper hearing conditions or room acoustics can be planned in advance as accurately as they can be remedied after the building has been erected.

For every requirement

The following descriptions of J-M Acoustical Treatments are not intended to recommend specific materials for specific conditions. Neither does space permit a more complete explanation of the wide variety of styles and sizes which are available nor the almost unlimited decorative effects which can be obtained. These descriptions are given only in a general way in reference to their advantages as corrective measures. Final choice can be made only after careful study of each individual problem.

A permanent and fire-proof acoustical treatment

Johns-Manville Sanacoustic Tile is a sound-absorbing interior finish consisting of a perforated metal tile containing J-M Rock Wool as the sound-absorbing element. The tile are made in four standard styles and sizes, permitting a great variety of patterns. They are held in place by means of metal tee bars which are first secured to the surface to be treated. When installed in buildings during the course of erection, all metal lath and plaster may be omitted back of the tile.

This photograph shows J-M Sanacoustic Tile being applied. Metal lath and plaster has been eliminated as unnecessary wherever this acoustical treatment is used. J-M Sanacoustic Tile is easy to install, yet makes a permanent, fire-proof job

Sanacoustic Tile is finished in baked enamel, giving it a very high light-reflecting value and a sanitary surface which may be easily cleaned with a damp cloth or sponge.

The standard color is a pleasing cream tone but the tile may be painted or decorated to obtain any desired effect without impairing the sound-absorbing efficiency of the treatment.

Sanacoustic Tile is also furnished predecorated in a wide range of designs and color combinations to harmonize with any interior decorative scheme. (A brochure illustrating some of the interesting effects which are secured in this way is available on request.)

This J-M Acoustical Material has the highest sound-absorbing efficiency of any commercial interior finish available. It is non-combustible and is the *only acoustical material which has been approved by the Underwriters' Laboratories.*

A large unit treatment for large areas

J-M Sanacoustic Holorib for Interiors is particularly adapted to large areas or places where it is desired to install an acoustical material in large units. This construction, made in lengths up to 12 feet, consists of sheets of

(Continued on page 20)

Thousands of auditorium
now have g

So exact is the science and practice of ac
Johns-Manville acoustical engineers, that ev
or both, can be provided with the proper acou
struction should be planned while the building
more exact acoustical conditions can be obtai
The pictures on these pages and elsewhere i
thousands of buildings in which corrective m
plied by Johns-Manville.

(*Above*) STUDIO "A," *one of the many National Broadcasting Company's studios in which good acoustical values have been provided with J-M Acoustical Treatment. The wall panels of this studio are so arranged that any size group of entertainers can be accommodated by exposing or covering definite areas of acoustical treatment*

C. Howard Crane, Detroit, Mich., Architect

(*Above*) THE BEAUTIFUL LARGE FOX THEATRE, *Detroit, Mich., in which J-M Acoustical Treatment was installed to correct the faulty acoustics existent at the time. Now everyone can hear distinctly even up in the top rows of the balcony.* (*Right*) *Excessive reverberation has been eliminated from the Tip Top Inn, of the Hotel Roosevelt, New Orleans, La., making this beautiful ballroom ideal for conventions, sale and club meetings, dinners, banquets and dances*

ns like these
good acoustics

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this book show but a few of the
easures have been successfully ap-

(Right) SEVERAL YEARS *after St. Mary's Roman Catholic Church, Sharpsburg, Pennsylvania, was completed, it was treated with Johns-Manville Acoustical Treatment. Yet all architectural lines and details were preserved in their entirety. All wall and ceiling surfaces, exclusive of plaster moulds and cornices, were finished with J-M Acoustical Treatment. The murals were applied to the treatment*

Harry J. Rill, Detroit, Michigan—Architect

perforated and enameled Holorib metal, backed by a Rock Wool sound-absorbing element. It also has a high sound-absorbing efficiency and is as fireproof and sanitary as Sanacoustic Tile.

A combination insulated roof and acoustical treatment

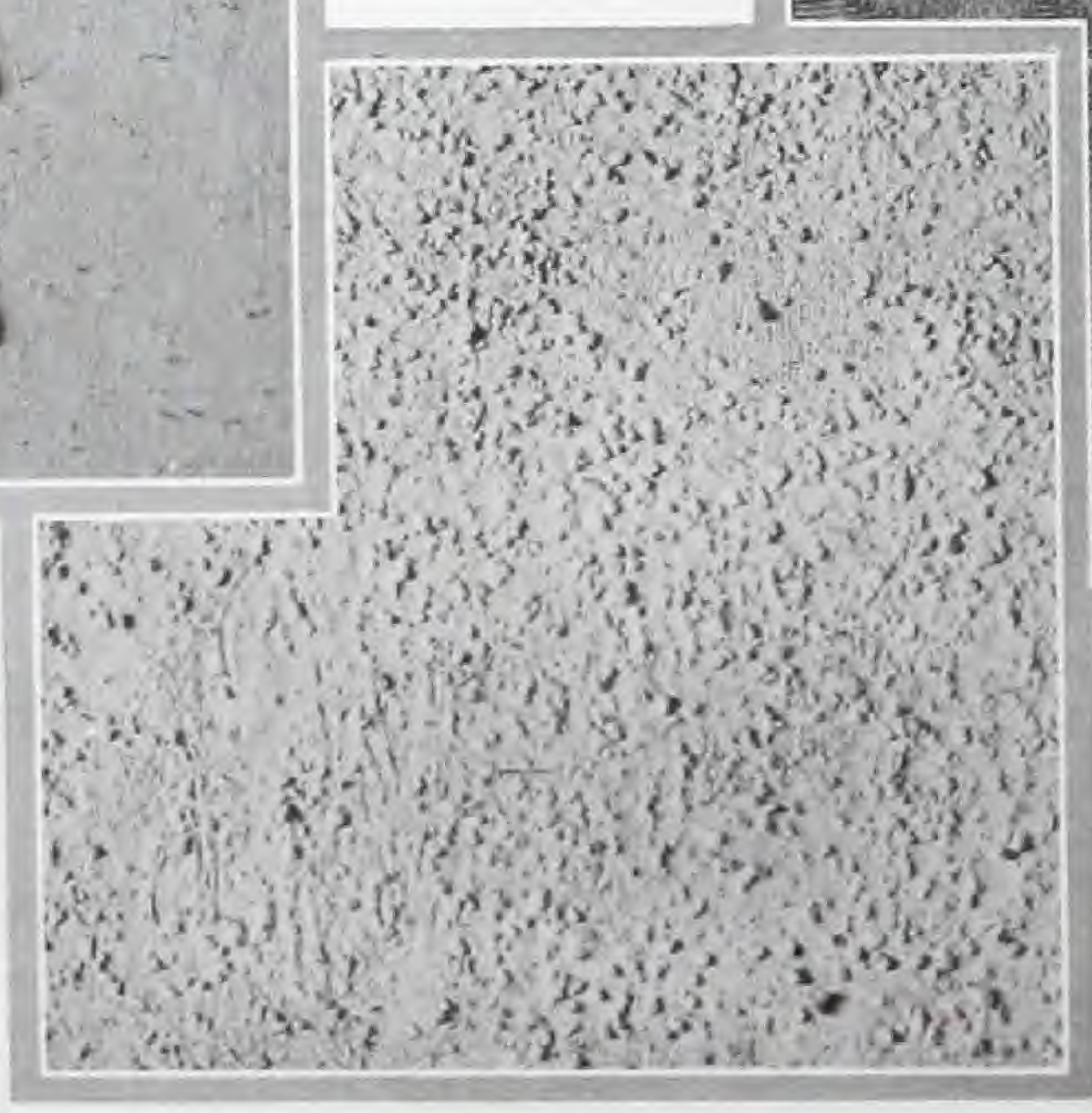
J-M Sanacoustic Holorib for Roofs is a combination acoustical ceiling, roof-deck, built-up waterproof roof and thermal insulation in one unit. It constitutes the lightest weight deck, ceiling, insulation and roof construction available. It is applicable to *new* construction in buildings of the type in which the underside of the roof slab forms the ceiling surface of the interior.

The new Transite Acoustical Tile*

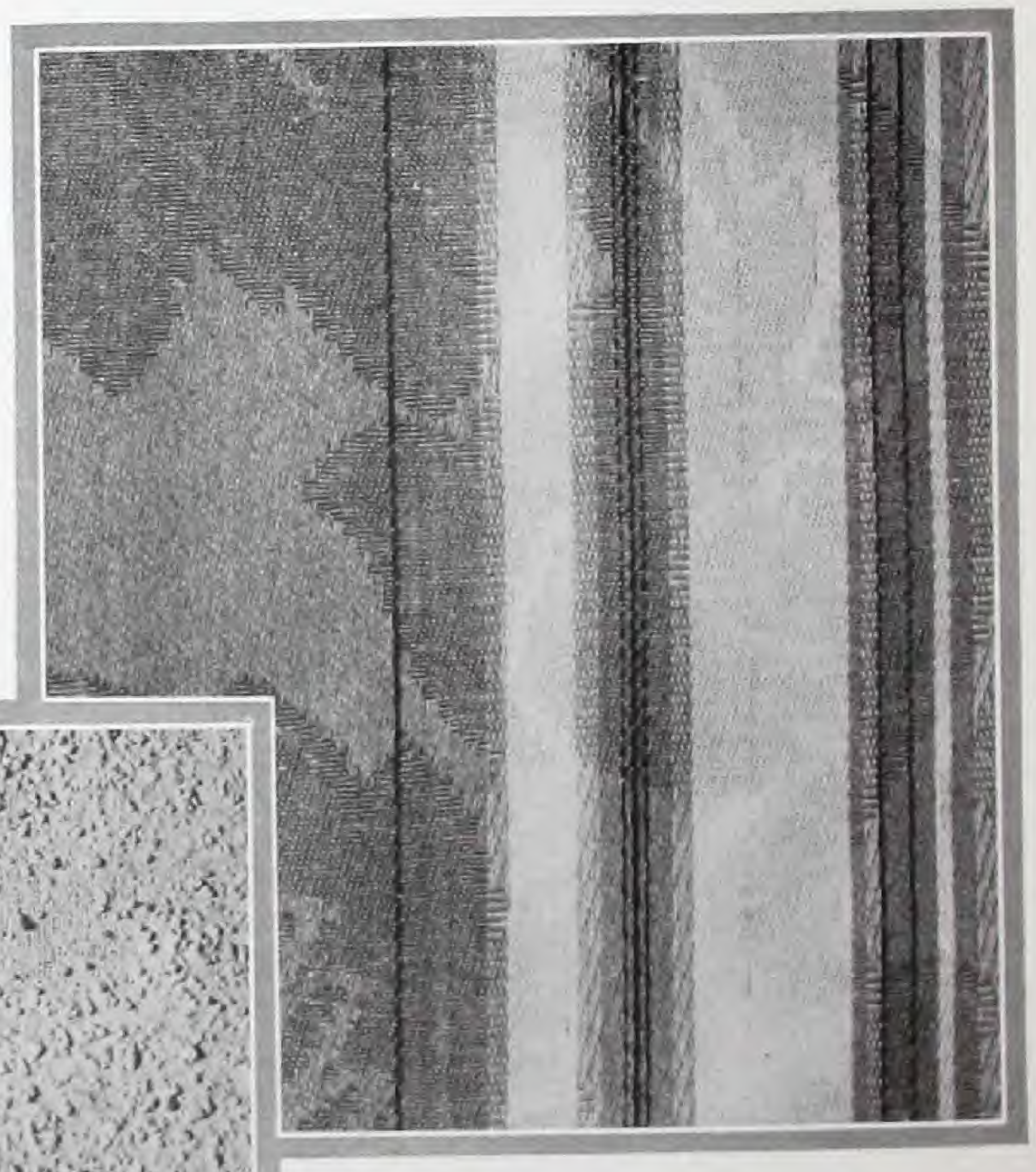
Transite Acoustical Tile, the latest addition to the Johns-Manville line of acoustical materials, is a combination of a 1″ thick rigid sound-absorbing block, faced with a perforated sheet of 3/16″ Transite* and backed with a sheet of asbestos paper securely cemented to the sound-absorbing block. The tile are available in two sizes, 6″ x 12″ and 12″ x 12″, with the edges of the block beveled on all sides.

Although it is possible to decorate Transite Acoustical Tile in any color that may be desired, material is available in three standard pleasing finishes—natural variegated gray, natural variegated buff and cream white enamel.

*J-M Transite is made of asbestos and Portland cement, and is used as a fireproof building material



(Above) Whenever desired plaster relief designs can be applied to J-M Nashkote treatment (Right) Plaster, rough, smooth or pebble effects, or paints of all descriptions can also be applied to J-M Nashkote



(Above) A section of a silk brocade finish as applied on J-M Acoustical Treatment. Muslins, tapestries, velvets, and other fabrics, as well as wall-paper, can also be used as interior finishes over these materials

A TREATMENT THAT RESEMBLES STONE

Here is another example of the decorative effects possible with J-M Acoustical Treatments. J-M Rockoustile is here shown as used in the Rathskeller at the University of Wisconsin, Madison, Wisconsin. No other decoration was used, the tile being left in the variegated state in which it comes

J-M Nashkote is as flexible as cloth

A distinctive feature of J-M Nashkote is its adaptability to domical surfaces and groined vaults as well as to flat ceilings. The sound absorbing element of this material is J-M Akoustikos Felt. Nashkote has great tensile strength, yet is as flexible as a piece of cloth. It is permanent, fire-resisting and sanitary and can be decorated as readily as any high grade plaster work. It is approved by building departments everywhere.

Nashkote is available in different thicknesses and in a large variety of finishes to meet any requirement or individual choice. Silk velours, tapestries, cretonnes or brocades may also be applied as finish surfaces, as well as special acoustical paint.

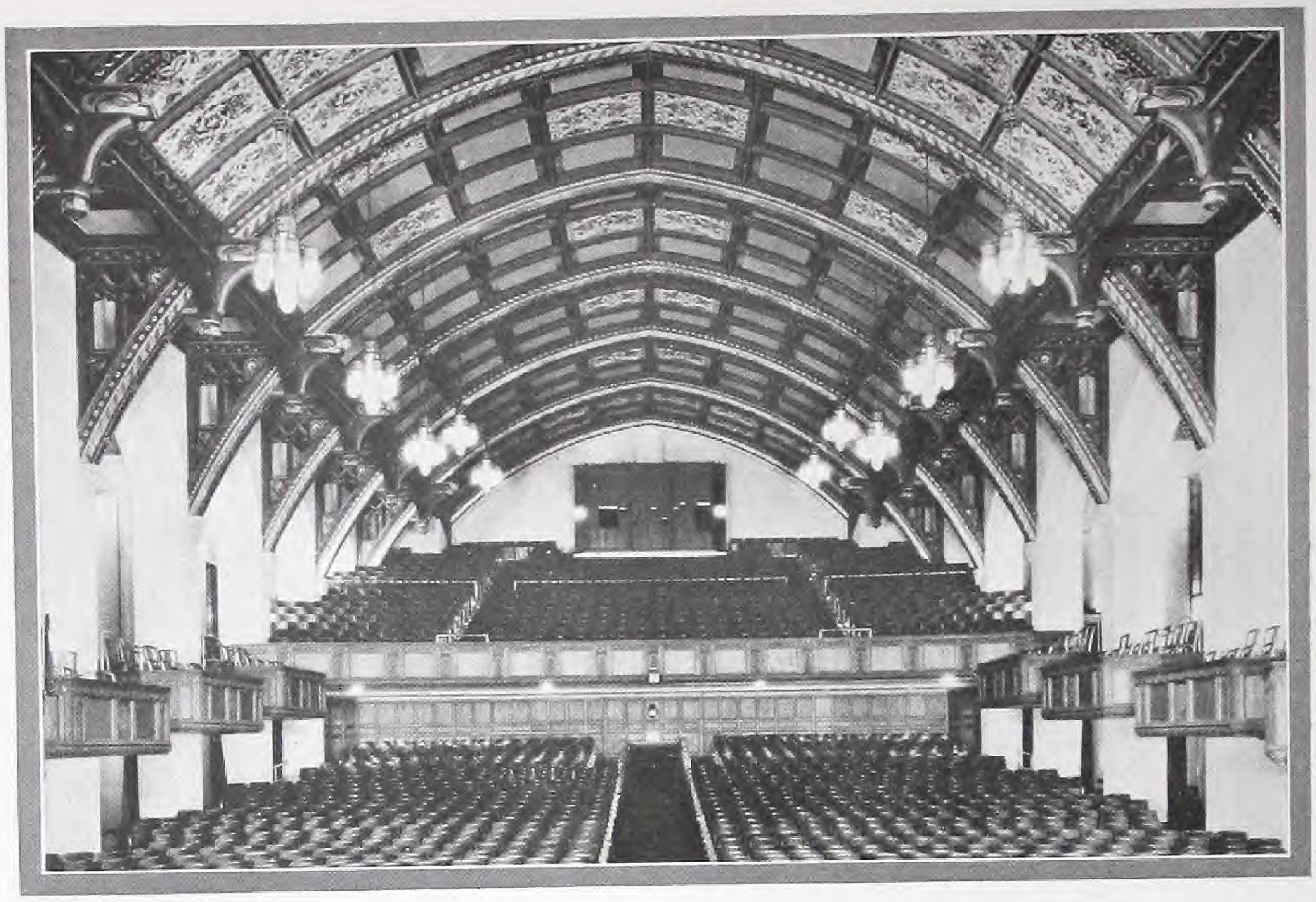
Here is a semi-rigid tile treatment

J-M Nashtile was developed to meet the need for a semi-rigid acoustical finish tile form possessing all the unique advantages of J-M Nashkote. The edges of the tile are beveled and finished with an attractive stone-like texture sprayed on the surface.

Being flexible and having a flexible face, Nashtile will conform to warped contours, groined arches and any other form of vaulted surfaces.

Resembles Travertine Stone

Johns-Manville Rockoustile is a tile form of sound-absorbing material made of Rock Wool having a distinctive texture somewhat similar in appearance to Travertine stone. This varies in different tile from a rather smooth surface to one possessing many voids, so that a random selection of the various textures in installation provides a blended effect which is very pleasing. Ceiling patterns are easily worked out to suit individual preferences.



FOR SMALL AUDITORIUM —OR LARGE

J-M Acoustical Treatments are applicable to any size auditorium or room. The photograph on the left is of the consistory Cathedral of the Detroit Masonic Temple, Detroit, Michigan, which again typifies the decorative possibilities obtainable with the use of J-M Acoustical Treatments

Rockoustile combines sufficient rigidity to be easily installed with enough porosity to make it a highly absorptive acoustical finish. It is easily cleaned and can be decorated if desired.

Sound-absorbing efficiencies of J-M Acoustical Materials

The coefficients of the various J-M Sound Absorbing Materials given below are figured on the basis of an open window, which is assigned a sound-absorbing value of 1 because it is assumed to absorb 100 per cent of the sound which reaches it. You will note that a number of the common interior finishes are also included in the table. By comparing the coefficients of some of these materials with those of the J-M materials, the high sound-absorbing efficiencies of the latter are at once apparent. For example, hard plaster on metal lath absorbs only about 2½ per cent of sound, while Sanacoustic Tile with a coefficient of .82 absorbs 82 per cent of sound, or over 30 times as much as the plaster.

The figures for the J-M Sound Absorbing Materials are taken from results obtained in tests by the U. S. Bureau of Standards and by the Riverbank Laboratories and give the efficiencies at sound frequencies of 512 cycles, the average of speech and music.

NAME OF MATERIAL	Units of Absorption per sq. ft. at 512 cycles
Hard plaster on metal lath	.025
Varnished wood	.03
Common brick wall, painted	.017
Glass, single thickness	.027
Marble	.01
Glazed tile	.017
Concrete and stone	.015
J-M Sanacoustic Tile 1¼″ thick	.82
J-M Sanacoustic Holorib Type SI Filler	.69
J-M Transite Acoustical Tile	.70
J-M Nashkote Type A	
½″ thick (*perforated after erection*)	.43*
¾″ thick (*perforated after erection*)	.51*
1″ thick (*perforated after erection*)	.67
J-M Nashkote Type B	
½″ thick	.37
¾″ thick	.47
1″ thick	.59
J-M Nashtile—¾″ thick	.38†
J-M Rockoustile 1″ thick	.60‡

*Bureau of Standards Test only.
†Riverbank Laboratories only.
‡Average of tests by Bureau of Standards and Burgess Laboratories.

Just a few of the places where good acoustics has been provided by Johns-Manville

IT WOULD be practically impossible to list all the churches, theatres, auditoriums, schools and studios in which J-M acoustical engineers have corrected acoustical defects and provided ideal hearing conditions. There are too many of them. Since the year 1911, over 13,000 installations of this type have been made. The following partial list of typical installations—made during the year 1930 only—will give you an idea of the scope of work in acoustical correction that Johns-Manville is prepared to do. This list consists of about 200 out of a total of over 1,500 buildings in which corrective measures have been applied during the past year.

CHURCHES

St. Vincent's Church	Los Angeles, Calif.
St. John's Episcopal Church	Stamford, Conn.
St. Andrew's Evang. Lutheran Church	Chicago, Ill.
Immanuel Evang. Lutheran Church	Elmhurst, Ill.
Embury M. E. Church	Freeport, Ill.
St. Francis Xavier Church	La Grange, Ill.
Epworth M. E. Church	Chicago, Ill.
First Westminster Presbyterian Church	Keokuk, Ia.
First Church of Christ Scientist	New Orleans, La.
Kleise Memorial Chapel	Grand Rapids, Mich.
St. Luke's Roman Catholic Church	St. Paul, Minn.
Second Baptist Church	Liberty, Mo.
Church of the Blessed Sacrament	Syracuse, N. Y.
Chapel of Church of Heavenly Rest	New York City
Church of the Holy Child Jesus	Richmond Hill, N. Y.
Centenary West End M. E. Church	Winston-Salem, N. C.
Broad Street Presbyterian Church	Columbus, Ohio
Queen of the Holy Rosary Cathedral	Toledo, Ohio
Finley Chapel-Oberlin College	Oberlin, Ohio
First Baptist Church	Shaker Heights, Ohio
Sixth Church of Christ Scientist	Portland, Ore.
Chapel of St. Francis Hospital	Pittsburgh, Pa.
Church of Covenant	Erie, Pa.
St. Anselm's Roman Catholic Church	Swissvale, Pa.
Coudersport Consistory	Coudersport, Pa.
St. Paul's Memorial Reformed Church	Reading, Pa.
First Presbyterian Church	Chattanooga, Tenn.
Third Church of Christ Scientist	Dallas, Texas
Trinity M. E. Church	Seattle, Wash.
St. Joseph's Church	Seattle, Wash.
Holy Communion English Lutheran Church	Racine, Wis.

THEATRES

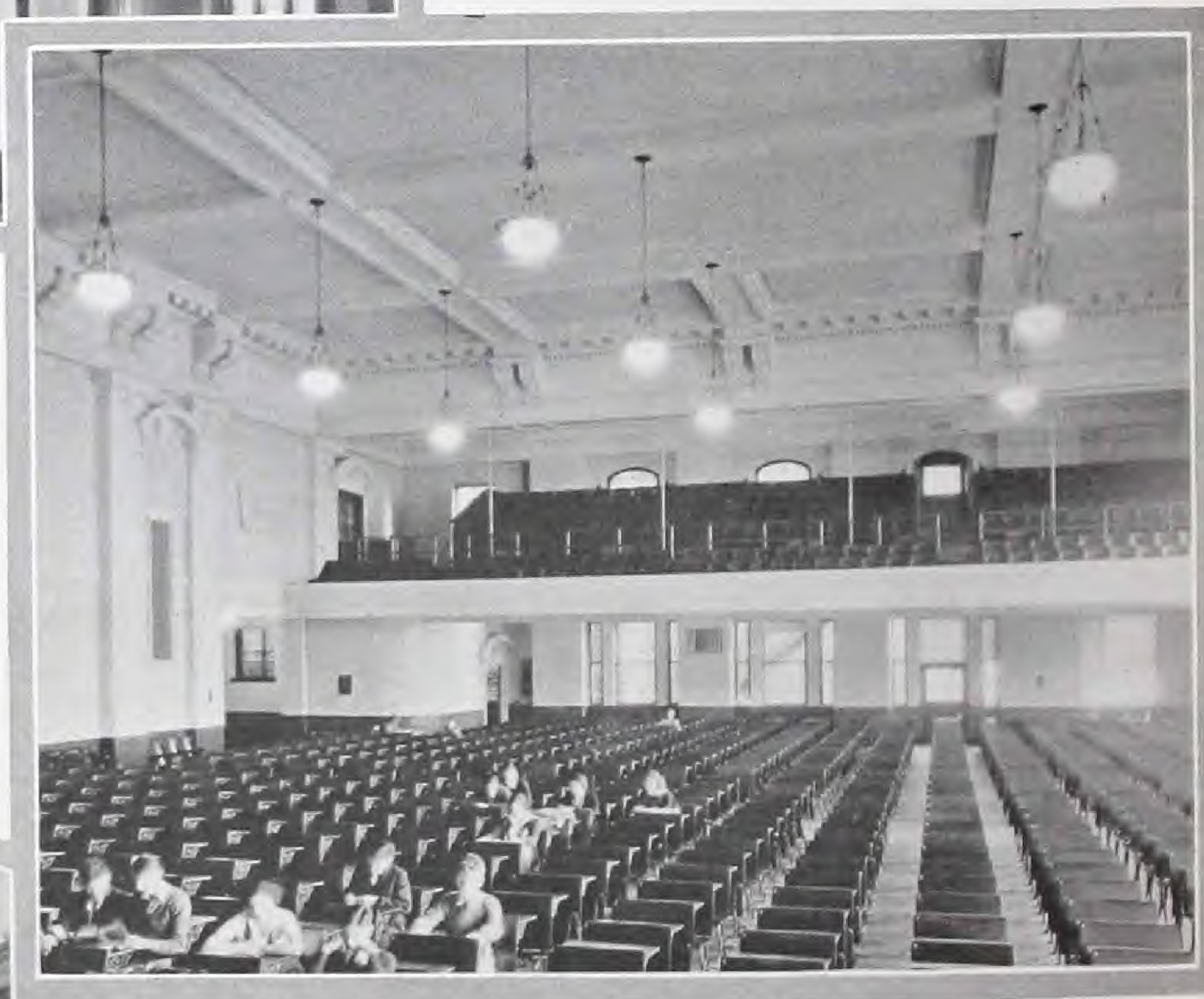
Saenger Theatre	Mobile, Ala.
Bay Point Theatre	Bay Point, Calif.
Whittell Theatre	Woodside, Calif.
Capitol Theatre	Toronto, Canada
Illington Theatre	Chicago, Ill.
Easterly Theatre	Chicago, Ill.
New Harmony Theatre	Chicago, Ill.
Randolph Theatre	Chicago, Ill.
Harvard Theatre	Chicago, Ill.
Bryn Mawr Theatre	Chicago, Ill.
Howard Theatre	Chicago, Ill.
Kenwood Theatre	Chicago, Ill.
Picadilly Theatre	Chicago, Ill.
Palace Theatre	Crown Point, Ind.
American Theatre	Indiana Harbor, Ind.
Downey Theatre	Hammond, Ind.
Liberty Theatre	Covington, Ky.
Saenger Theatre	New Orleans, La.
Strand Theatre	Shreveport, La.
Columbia Theatre	Baton Rouge, La.
Keith Memorial Theatre	Boston, Mass.
Orpheum Theatre	Foxboro, Mass.
Cape Play House	Dennis, Mass.
Inman Square Theatre	Cambridge, Mass.
Regent Theatre	Grand Rapids, Mich.
Rialto Theatre	Detroit, Mich.
Newberry Theatre	Newberry, Mich.
Marion Theatre	Clarksdale, Miss.
Majestic Theatre	Jackson, Miss.
Saenger Theatre	Meridian, Miss.
Capitol Theatre	Concord, N. H.
Castle Theatre	Raton, N. M.
Verona Theatre	New York, N. Y.
Eastwood Theatre	Toledo, Ohio
Orpheum Theatre	Oklahoma City, Oklahoma
Ritz Theatre	Tulsa, Oklahoma
Patricia Theatre	London, Ontario, Canada
Harris Amusement Company	Pittsburgh, Pa.
Roosevelt Theatre	Swoyersville, Pa.
Varsity and Arcadia Theatres	Dallas, Texas
Burlington Theatre	Burlington, Vt.
Egyptian Theatre	Park City, Utah

SCHOOLS, COLLEGES and UNIVERSITIES

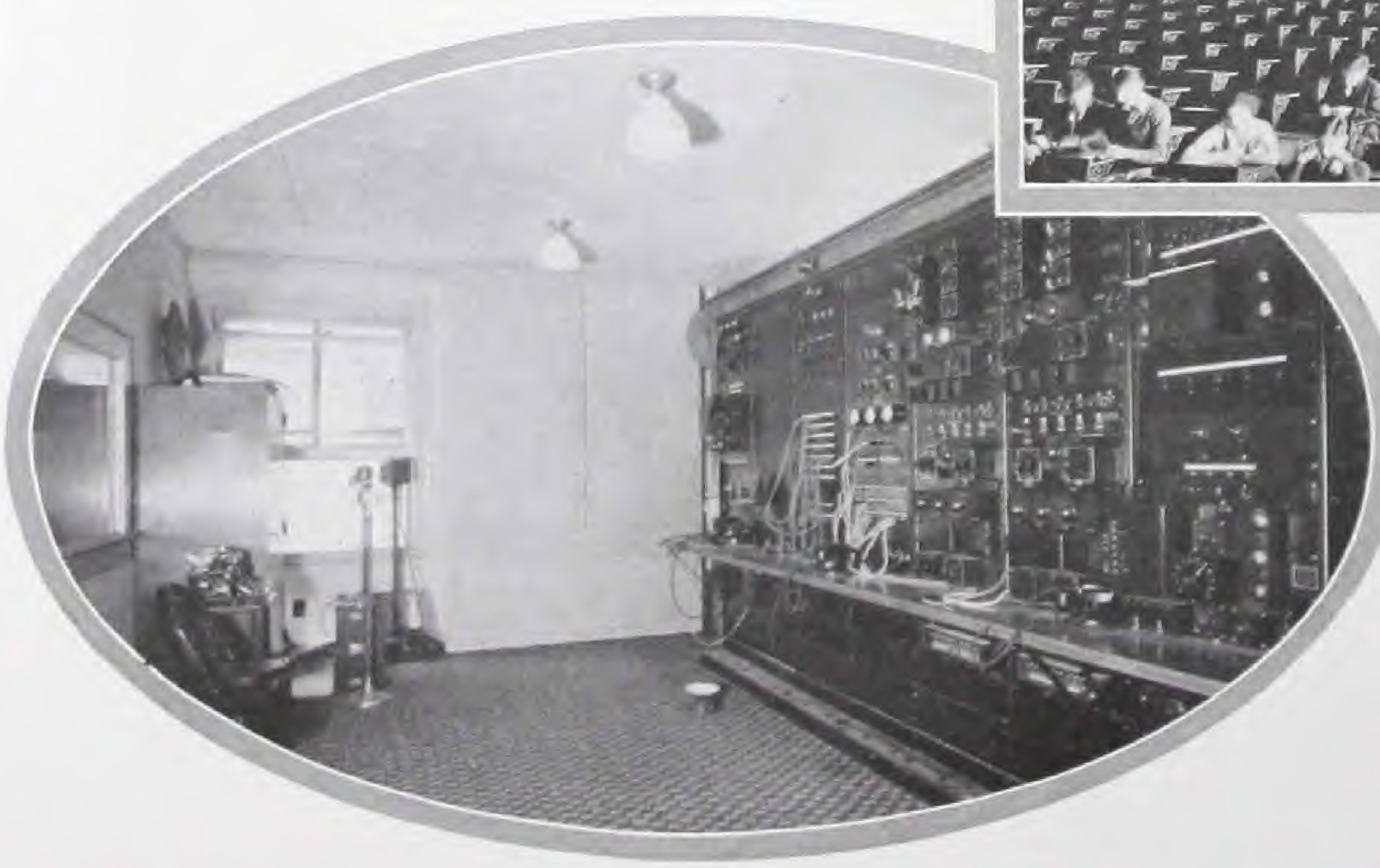
Murphy High School	Mobile, Ala.
Little Rock Sr. H. S.	Little Rock, Ark.
Tower Hill School	Wilmington, Del.
Schools No. 81, 49, 82, and 56	Indianapolis, Ind.
High School	Wathena, Kan.
Kansas University	Lawrence, Kan.
Legouri High School	New Orleans, La.
Vivian High School	Vivian, La.
Onachita Parish High School and Junior High School	Monroe, La.
Bowdoin College	Brunswick, Me.
Massachusetts Agricultural College	Amherst, Mass.
Sough High School	Worcester, Mass.
Lowery School	Dearborn, Mich.
Gabriel Richards School	Grosse Pointe, Mich.
Plymouth High School	Detroit, Mich.
Robert Trombley School	Detroit, Mich.
Battle Creek Public School	Battle Creek, Mich.
Grosse Pointe High School	Grosse Pointe, Mich.
Fordson High School	Detroit, Mich.
So. St. Paul High School	So. St. Paul, Minn.
Phillips Exeter Academy	Exeter, N. H.
Linden School	Linden, N. J.

(Continued on page 26)

(*Left*) FAULTY HEARING *conditions, produced by the inverted V-shaped ceiling and the hard-surfaced interior finishes used in the First Baptist Church, Shaker Heights, Ohio, were extremely annoying to the congregation and trying to the minister. Now that the church has been treated by Johns-Manville, the minister's voice carries clearly to every part of the church and every member of the congregation can hear distinctly. Organ music and the singing of choir flows to every pew in natural tones*



(*Right*) REVERBERATION *in the auditorium of the Broadway High School, Seattle, Washington, was reduced by J-M Acoustical Treatment, from a period of 8 seconds' duration when empty to 2.6 seconds*



(*Left*) THE CONTROL ROOM *of Station WFAA, Dallas, Texas, was treated with J-M Sanacoustic Tile. The treatment here was applied to absorb the major part of all sounds and thus prevent them from interfering with the programs*

(*Left*) ANOTHER THEATRE *where J-M Sanacoustic Tile was used — the Plaisance Theatre in Chicago, Illinois. Note how the treatment on the ceiling and upper rear wall blends with the tile effect used as wainscoting*

(*Right*) IN THE $2,500,000 *Queen of the Holy Rosary Cathedral, Toledo, Ohio, the acoustics were planned in advance of construction. J-M Sanacoustic Panels, with two-inch Rock Wool slabs as the sound absorbing medium, were chosen as the acoustical treatment. The beautiful decoration is applied to the treatment. Note that several of the stars and octagon shapes are unfinished in these photographs. These will be installed after painting.*

Wm. R. Perry, Pittsburgh, Pa., Architect

(*Left*) IT IS UNNECESSARY *to "strain" one's ears in the Civic Auditorium, at Seattle, Washington, for the huge auditorium has also been corrected with J-M Acoustical Treatment and it now has ideal hearing conditions*

These and hundreds of other places now have good acoustics

(*Continued from page 23*)

School No. 21	Elizabeth, N. J.
Morristown High School	Morristown, N. J.
Canastota High School Gym.	Canastota, N. Y.
Otego Central School	Otego, N. Y.
Central Rural School, District No. 1	Waterville, N. Y.
Washington Junior High School	Rochester, N. Y.
Benjamin Franklin School	Rochester, N. Y.
Chautauqua School	Chautauqua, N. Y.
Lake George High School	Lake George, N. Y.
Sacred Heart Academy	Eggertsville, N. Y.
Senior High School	Amsterdam, N. Y.
Savannah High School	Savannah, N. Y.
Cazenovia School	Cazenovia, N. Y.
Hamilton College	Clinton, N. Y.
Forest Hill Drive School	Syracuse, N. Y.
Newark Valley School	Newark, N. Y.
Penfield High School	Penfield, N. Y.
School No. 9	Mt. Vernon, N. Y.
Newton High	Newton, N. C.
Duke University	Durham, N. C.
Jackson Township High School	Fox, Ohio
John Marshall High School	Cleveland, Ohio
Roosevelt High School	Klamath Falls, Ore.
Marquan Hill Medical School	Portland, Ore.
Beaumont and Brooklyn Schools	Portland, Ore.
Lincoln High School	Elwood City, Pa.
Carnegie Tech	Pittsburgh, Pa.
Chapel of Munhall High School	Munhall, Pa.
Prospect School	Mt. Washington, Pa.
Bryn Mawr College	Bryn Mawr, Pa.
Bucklin St. Junior High School	Providence, R. I.
McHarrig Medical College	Nashville, Tenn.
High School	Memphis, Tenn.
Harlingen High School	Harlingen, Texas
Broadway High School	Seattle, Wash.
Anderson Hall, University of Washington	Seattle, Wash.
Marshall College	Huntington, W. Va.
Junior High School	Waukesha, Wis.
St. James Parochial School	Wausau, Wis.
Rathskeller, University of Wisconsin	Madison, Wis.
St. Mary's Academy	St. Francis, Wis.
Lawrence College	Appleton, Wis.

BROADCASTING STUDIOS — RADIO AUDITION ROOMS

N. B. C. Studios	San Francisco, Calif.
Great Lakes Broadcasting Co.	Chicago, Ill.
N. B. C. Studios	Chicago, Ill.
Station WSMB	New Orleans, La.
Station WCAO	Baltimore, Md.
Station WCKY and Station WMBC	Detroit, Mich.
L. Bamberger & Co.	Newark, N. J.
2 Broadcasting Studios, Station WOR	
Judson Radio Program Co.	New York, N. Y.
N. B. C.—Station WEAF	New York, N. Y.
Columbia Broadcasting Co.	New York, N. Y.
RCA Radiotron Co.—Demonstration Room	New York, N. Y.
Television Studio—Columbia Broadcasting Co.	New York, N. Y.
Station KTLC—Houston Post Dispatch	Houston, Texas
Station KSAT	Fort Worth, Texas
Wisconsin Broadcasting Co. Studios	Madison, Wis.

CLUBS, FRATERNITIES and SOCIETIES

Hartford Club	Hartford, Conn.
American Women's Club	New York, N. Y.
Masonic Temple Ball Room	Cincinnati, Ohio
Jaffa Shrine Temple	Altoona, Pa.
Scandinavian-American Fraternity	Eau Claire, Wis.
Minneapolis Athletic Club	Minneapolis, Minn.
Quadrangle Club	Chicago, Ill.
Union Club	Boston, Mass.
Victor Lawson Y. M. C. A.	Chicago, Ill.
Woman's City Club	Detroit, Mich.
Y. M. H. A.	Baltimore, Md.
Y. W. C. A.	Akron, Ohio
Y. W. C. A.	Milwaukee, Wis.
Y. M. C. A.	Akron, Ohio
Y. M. C. A.	Kenosha, Wis.

COURT ROOMS

State Building Court Room	Los Angeles, Calif.
Montgomery Co. Court House	Rockville, Ind.
Court Rooms A & B & No. 7	Minneapolis, Minn.
Hunes Co. Court House	Jackson, Miss.
Camden Co. Court House	Camden, N. J.
Cayuga Co. Court House	Auburn, N. Y.
Franklin Co. Court House	Malone, N. Y.
Cuyahoga Co. Court House	Cleveland, Ohio
Providence Co. Court House	Providence, R. I.
Marshall Co. Court House	Lewisburg, Tenn.
U. S. Customs & Court House	Memphis, Tenn.
San Augustine Court House	San Augustine, Texas
Kings Co. Court House	Seattle, Wash.
Skagitt Co. Court House	Mt. Vernon, Wash.

MISCELLANEOUS AUDITORIUMS

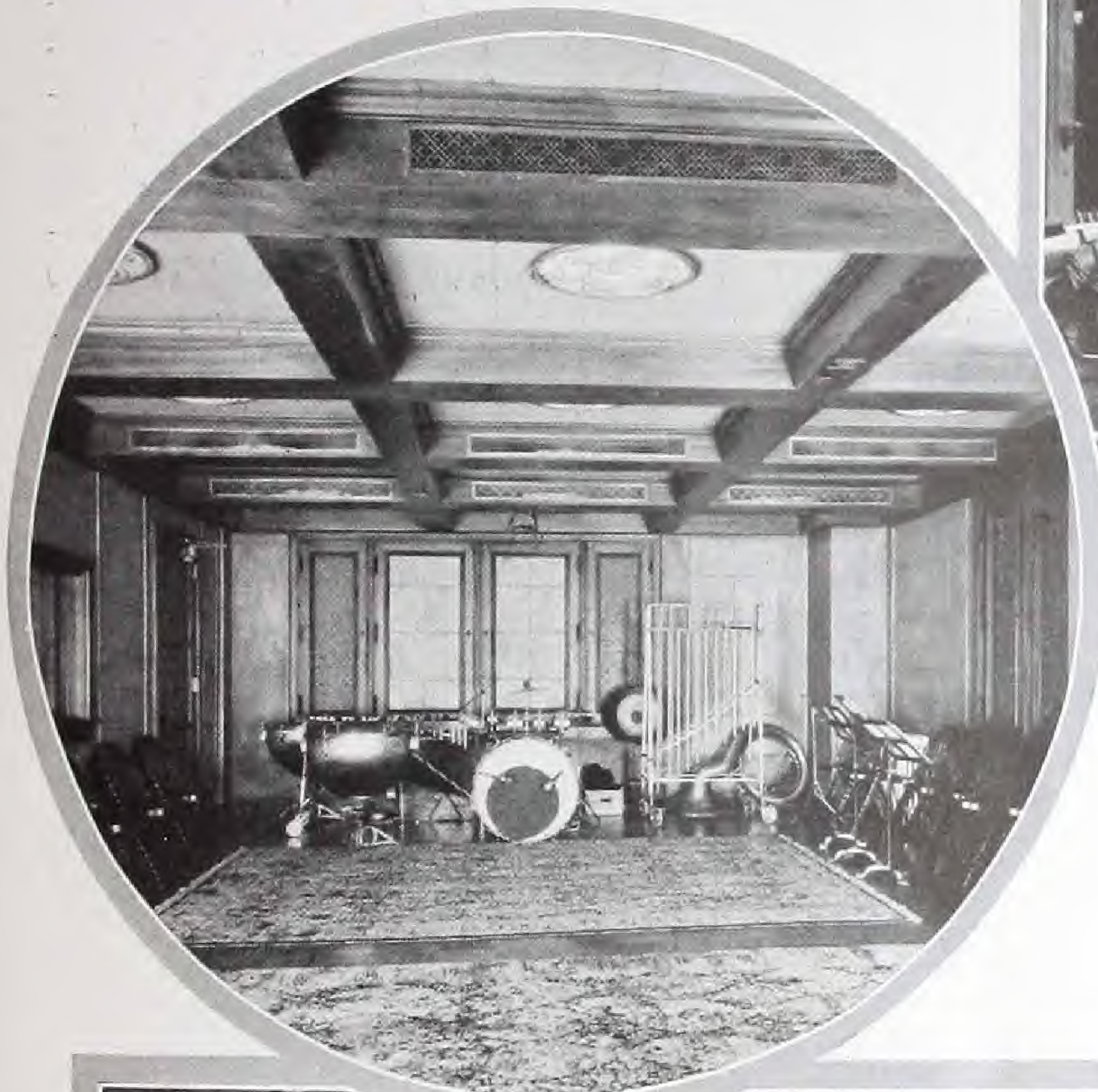
Emeryville Veterans War Memorial	Emeryville, Calif.
Veterans War Memorial	Livermore, Calif.
Bridges Auditorium	Claremont, Calif.
Nurses Home	Grand Rapids, Mich.
Amer. Tel. & Tel. Assembly Room	New York, N. Y.
General Electric Company Club House	Schenectady, N. Y.
White Institute of Organ	New York, N. Y.
N. Y. Times Annex Television & Radio Room	New York, N. Y.
Toledo Board of Trade	Toledo, Ohio
Portland Library Association	Portland, Ore.
Westinghouse Elec. & Mfg. Co. Auditorium	East Pittsburgh, Pa.
Corn Palace—Municipal Auditorium	Mitchell, S. D.
Fairmont Hotel Ballroom	San Francisco, Calif.
Hotel Roosevelt Banquet Hall	New Orleans, La.
The New Waldorf Astoria Hotel	New York, N. Y.
Commodore Perry Hotel	Toledo, Ohio
Baker Hotel	Dallas, Texas
St. George Hotel	Brooklyn, N. Y.

FOREIGN

Air Ministry, Croyden	London, England
British Broadcasting Co., Clapham	London, England
British & Dominions Films, Elstree	London, England
British Movietones, Ltd.	London, England
Forum Theatre, Fulham	London, England
Gainsborough Studios	London, England
Gaumont Studios	London, England
Globe Cinema, Clapham	London, England
Olympic Kiné Studios	London, England
Western Electric Co., Ltd.	London, England
Wireless Music, Ltd.	London, England
Commodore Cinema	Liverpool, England
Deansgate Cinema	Manchester, England
Picture Palace	Greenock, Scotland
Gaumont Palace	Paris, France
Salle Pleyel	Paris, France
Paramount Studios	Paris, France
Pathé-Nathan Studios	Paris, France

Pictures that tell a story of good acoustics

(*Below*) THIS BROADCASTING STUDIO *of Station WFAA, Dallas, Texas, like hundreds of others all over the country, has correct acoustical values for broadcasting speech and music, due to J-M Acoustical Treatment*



(*Above*) FROM COLUMBUS, OHIO, *Rev. J. Harry Cotton, Minister of the Broad Street Presbyterian Church, writes us: "Previous to the treatment by your company, I had to speak directly to the back door and could not turn to either side lest the opposite side would not hear what I said. The echo was very bad and in the evening service it was almost impossible to make one's self heard. . . . Since the installation of the J-M Treatment all difficulty has been removed. One may stand and address a far corner of the auditorium and the people in the opposite corner hear distinctly"*

(*Below*) IN THIS LODGE ROOM *of the Masonic Temple, St. Louis, Missouri, J-M Acoustical Treatment was applied for the dual purpose of clearing the air for speech and for quieting noise*

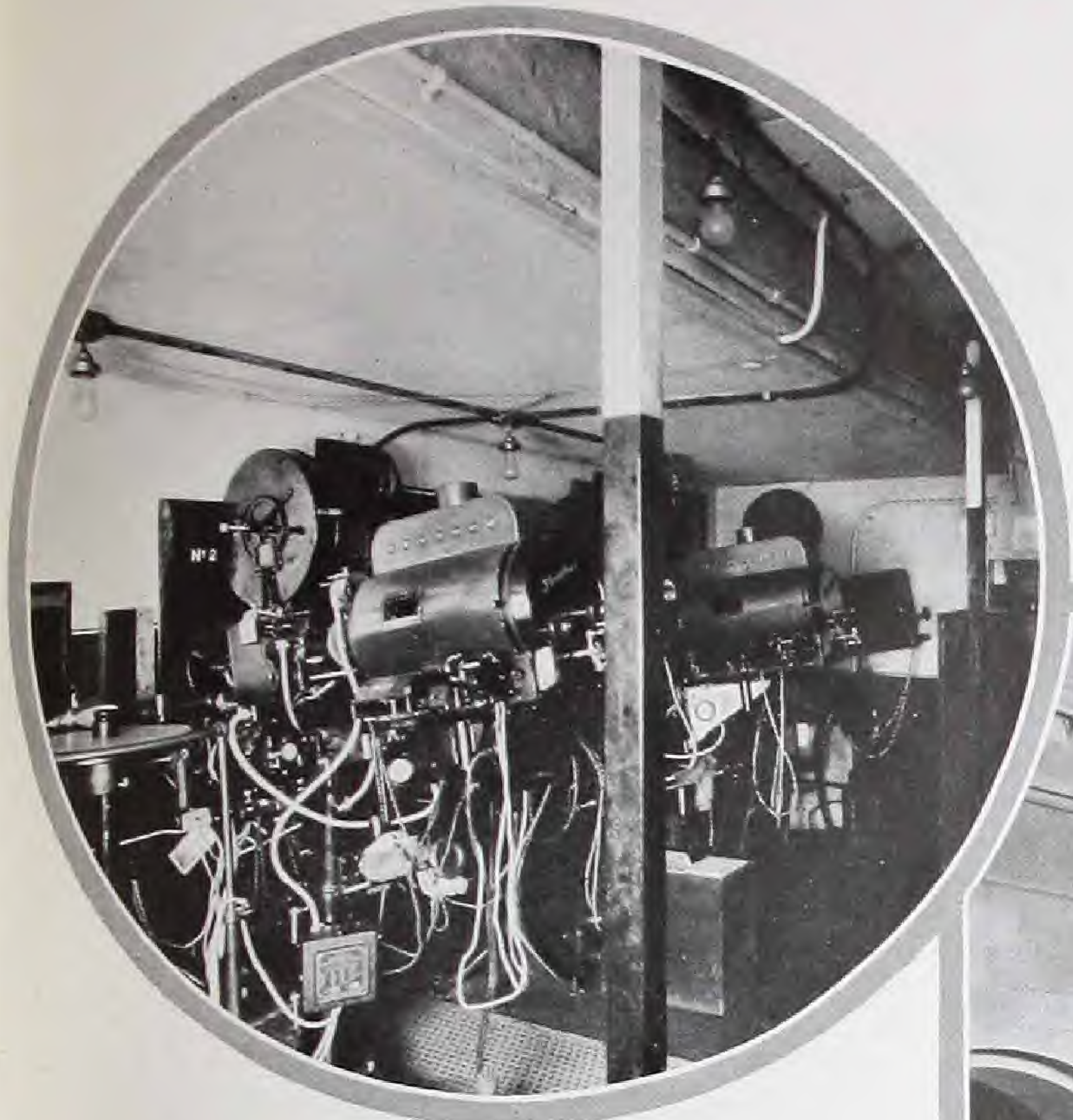
(*Above*) LECTURES CAN BE HEARD *at Hamilton College, Clinton, New York. Before treatment, students had to pay the strictest attention and tense concentration. The lecturer had to face his class continuously. Now, this and another lecture room are ideal acoustically. Everyone can hear and it calls for no effort on the lecturer's part to be understood*

Wherever there is a need for good acoustics

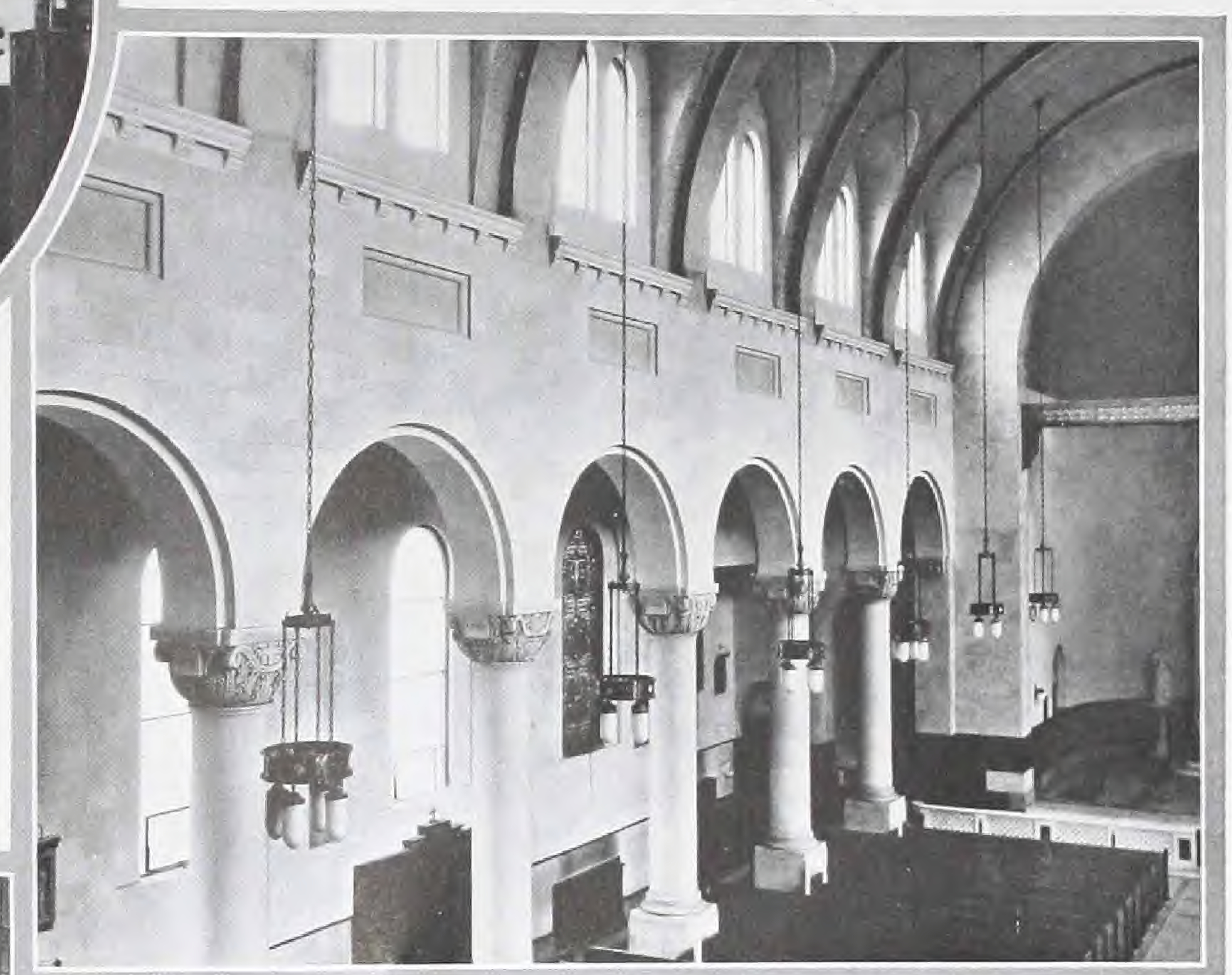
(*Left*) ACOUSTICALLY CORRECT CHAPEL *of the Edwards Brothers Funeral Parlors at Los Angeles, California. The services which are conducted here can be heard clearly and distinctly by every person present and music is undistorted*

(*Right*) IN THE BEAUTIFUL *St. Gabriel's Roman Catholic Church, Hazleton, Pa., the entire groined ceiling of the nave and aisles was treated with sand-finish J-M Nashkote Acoustical Treatment and lined to represent stone vaulting, giving this church not only good acoustics but beautiful interior finish in keeping with the general architectural design. Peter B. Sheridan, Hazleton, Pa., Architect*

(*Left*) GOOD ACOUSTICS *was provided in the Lincoln Theatre, of the University of Illinois, Chicago, Illinois, with J-M Sanacoustic Tile. Spaces between tile in this installation were filled with plaster of Paris*



(*Left*) NOISE PRODUCED *in the projection room of the Liberty Theatre, Pittsburgh, Pa., does not enter the auditorium to annoy the patrons. J-M Sanacoustic Tile absorbs all sounds produced here, keeping noise down to an undisturbing level*



(*Below*) CONSIDERED BY MANY PEOPLE *as an outstanding example of modern church architecture, St. Joseph's Cathedral, at Seattle, Washington, is also correct acoustically. Ideal hearing conditions for the auditorium were planned when this church was designed*

(*Above*) FOR FIVE YEARS *the congregation and the priests of the St. Anselm Church, Pittsburgh, Pa., were annoyed by faulty acoustics. After it was corrected by Johns-Manville, Rev. Daniel O'Connell, Pastor of the Church, wrote: "There is now no part of the church where the speaker cannot be heard clearly and distinctly. . . . The material applied has not only corrected the reverberation but it has beautified the church"*

(*Right*) AN EXTERIOR VIEW *of the beautiful St. Joseph's Cathedral of Seattle, Wash.*

CHAPEL OF THE INTERCESSION, NEW YORK CITY

One of the many large churches in which good hearing conditions have been provided by the use of Johns-Manville Acoustical Treatment is the Chapel of the Intercession, in New York City. The sound-absorbing material was applied to all the ceiling panels between beams and purlins, and the surface of the material was decorated in harmony with the beautiful architecture of the interior
Cram, Goodhue & Ferguson, New York, Architects

A resume of some recent developments in acoustical science

For you who are interested in the more scientific phase of acoustical work, we present on the following pages some of the most recent developments in the science of acoustics as it pertains to modern buildings

IN recent years the scope and complexity of acoustical problems has increased many fold. As a result, a number of scientists and research workers have turned their minds to the problem and much has been done to broaden and extend the fundamental theory. Some of this work is of sufficient importance to deserve mention in this volume.

Since reverberation is the most common defect to be found in auditoriums, let us consider first what recent research has added to our knowledge on this subject. The simple Sabine formula, $t = .05V/as$,* makes certain general assumptions. It assumes a typical standard source having an initial intensity level of sixty decibels above threshold. It assumes a uniform distribution of sound energy throughout the room and hence a uniform reverberation everywhere in the room. It assumes that the room is not excessively dead, for obviously in a very dead room the reverberation ought to approach zero, whereas according to this formula it can never become smaller than a certain arbitrary value fixed by the limiting value of the fraction when "a" becomes 100%. Likewise this formula assumes that all the absorption in a room takes place at the boundaries of the room, i.e., that there is no loss due to absorption in the air itself.

*t = period of reverberation in seconds.
V = volume of room in cu. ft.
a = Average absorption coefficient of interior surfaces.
s = Surface area in sq. ft.

First consider this assumption of a standard initial intensity level. Let a continuous source sound for a space of a few seconds within a room, and it will build up to a certain value, depending upon the energy flow from the source and the amount of absorbing material in the room. The period of reverberation will depend upon the intensity to which the sound builds up, increasing as the logarithm of this value. Now, if we assume an average initial level, and base all calculations upon this figure, we may come very close to actual room conditions or may introduce a considerable error, depending on how nearly the actual conditions correspond to this arbitrary value. Obviously, the period of reverberation from the note of a single violin would be much shorter than the period resulting from the strains of a large concert orchestra. And both these conditions may be quite different from the arbitrary level assumed. Likewise the same violin will produce one level and one period of reverberation in a room of low absorptive power, and quite another level as well as a different reverberation in a more highly absorbent space.

Dr. Paul E. Sabine has suggested a formula which partially meets these objections,

$$t = \frac{.0083V}{as}(9.1 - \log 10a)$$

Here the quantity in the parentheses represents a correction factor for the loudness of the source as governed by the amount of absorption in the room. It will be

Source	Power Output	Substitute for Value 9.1
Average speech	10 microwatts	8.0
Declamatory speech	500 microwatts	9.7
Singing voice	1,000 to 30,000 microwatts	10.0-11.4
Theater Horn at +8 level (add .1 for each db. above +8)	6,000 microwatts	10.8
Piano	8,200 microwatts	10.9
Pipe Organ	8,200 to 800,000 microwatts	10.9-12.9
15 piece Orchestra	35,000 microwatts	11.5
Bass Saxophone	2,800 microwatts	10.4
Clarinet	1,500 microwatts	10.2

The power output of various sound sources

noted that if the quantity in the parentheses is equal to 6, then the formula reduces to the standard $t = .05V/as$. Since this 6 corresponds to an initial level of 60 db., it will be seen that the standard formula is really only a special case of this more general one wherein the assumption of an initial loudness of 60 db. is justified.

However, this formula also assumes a standard energy output from the source (resulting in the figure 9.1) and we are still without a means of correcting our figures according to the probable variation in the power of the source itself. Recent research, however, has added tremendously to the knowledge on this subject, and it should now be possible to present a table of figures for sources of different power to be substituted for the 9.1 in the formula. The table on page 31 is suggested for that purpose, with the hope that as more work is done along these lines it may be made more complete.

The use of the figures in the table (p. 31) will give the actual reverberation time with different sources. They are of interest in articulation testing work, and other experimental measurements made under conditions of actual use. They cannot of course be used in correcting auditoria to the optimum times given in chart No. 2 since these optima are all based on the standard formula.

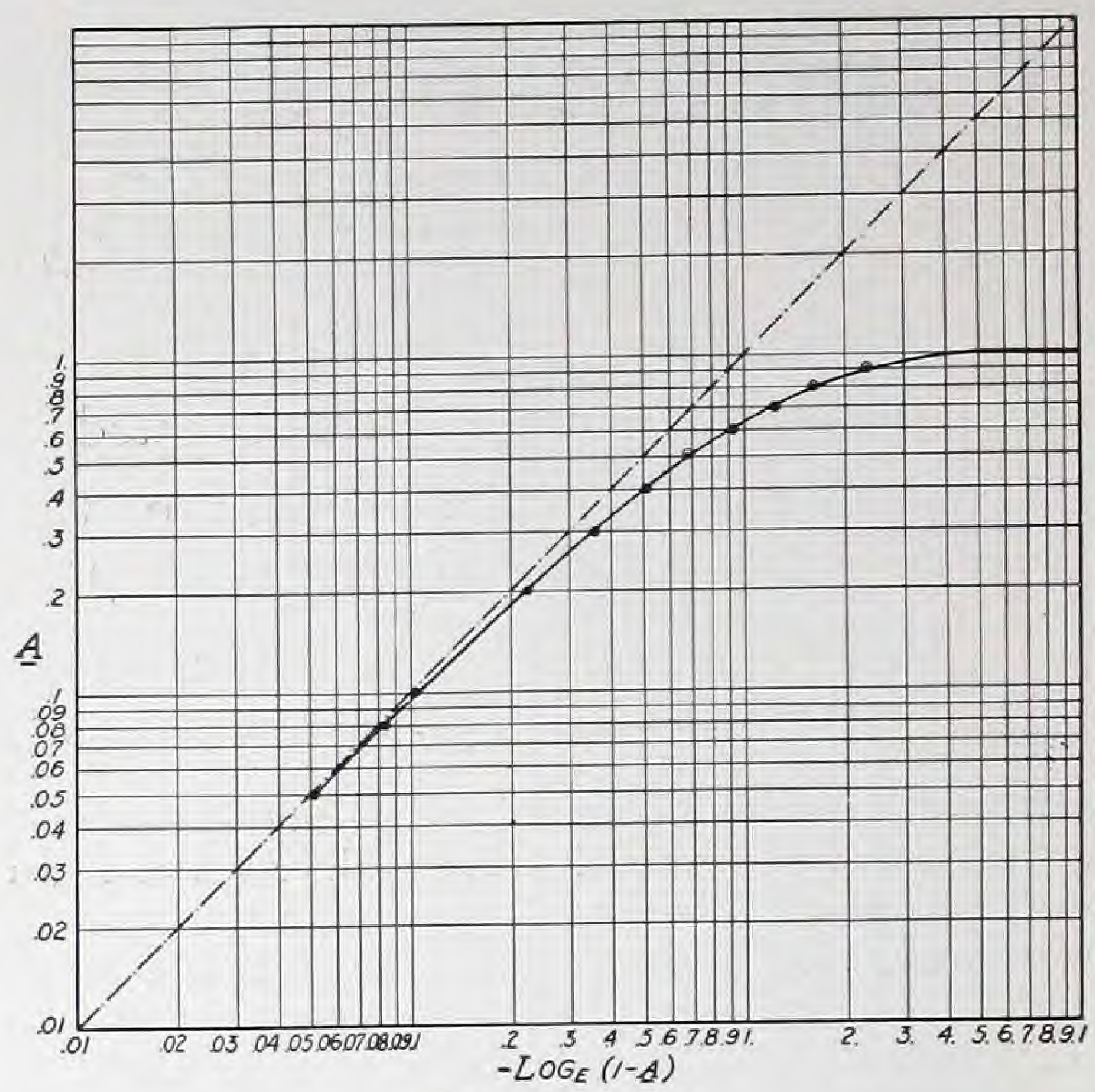


CHART NO. 1

Showing relation of a to $-\log_e (1-a)$

Distribution

Now let us return to the second assumption mentioned above, that there is uniform distribution of sound throughout the room. Where the room is of simple rectangular shape with no deep offsets, beams, balconies, etc., this assumption is justified. On the other hand, certain recent work, notably that of Dr. Carl Eyring of the Bell Telephone Laboratories, has demonstrated conclusively that there may be two or more periods of reverberation in different parts of the same room. As yet there is little quantitative information, but it is a very desirable precaution to study each auditorium for possible areas wherein the reverberation might be different from that of the main room. Likewise, if a room is "dead" care should be taken to avoid so-called "two-dimensional reverberation," which may result from multiple reflection between two highly reflecting areas set opposite one another in an otherwise absorbent room. A practical application of both lines of reasoning is found in the modern theatre. Here, under-balcony spaces should receive special treatment in the analysis (see Johns-Manville Data Sheets, 8-X-7, 8-X-7-A). In the body of the theatre walls rather than the ceiling should be treated because floor areas are nearly always absorbent, and with an absorbent ceiling and bare walls, the cross reflections between walls may completely throw out the calculations. Sound distribution also is usually faulty under such conditions.

With reference to the matter of very "dead" rooms, it should be said that none of the auditoriums which were considered in the development of the original Sabine formula, were of this classification. The extremely low periods found today in radio studios and sound film studios were unheard of. Nevertheless, corrections of this kind are becoming increasingly numerous, and for this reason the formula developed by Dr. Carl Eyring and Mr. R. F. Norris of the Burgess Laboratories should be mentioned. It is written

$$t = \frac{.05V}{-s \log_e (1-a)}$$

A brief examination will show that this formula is identical to the more familiar one if the term "as" is substituted for the denominator, or if "a" is substituted for the term $-\log (1-a)$. Chart No. I gives a method of converting from one quantity to the other.

It will be observed that for the majority of cases the error introduced by the simpler formula is negligibly small. A good working rule is that the more direct formula may be used where the error is less than 10 per cent.

Atmospheric absorption

Return now for a moment to the last assumption mentioned above—that all the sound absorption takes place at the boundaries of the room. Otherwise stated, we assume that none of the sound energy is dissipated in the atmosphere, but only during the course of reflection. There has been an increasing weight of evidence to show that this assumption is not justified, particularly at the upper frequencies. Recently some very excellent work by Dr. V. O. Knudsen has demonstrated the fact that a factor must be added to the reverberation formula in the following manner to take care of variations in the relative humidity:

$$t = \frac{.05V}{-s \log_e (1-a) + 4mV}$$

At frequencies below 2000 cycles this quantity "m" is almost infinitesimal, and at 2000 cycles it may be neglected in most cases. However, at 4000 cycles, it becomes of real importance, assuming a value of about .0033 at 20% relative humidity. In present day acoustical science, the reverberation at these upper frequencies is not of extreme importance, but there may easily come a time, as our understanding of tone quality grows, when these facts may assume considerable significance.

Acceptable periods of reverberation

After the method of calculating the reverberation has been determined there still remains the moot question of what the ideal reverberation—the so-called "optimum period" should be. This term "optimum" is extremely misleading. There is no "best" period of reverberation for an auditorium, and the figure selected invariably represents a compromise between various conflicting requirements. The value finally used is by no means arbitrarily fixed; like all compromises it may be readjusted to meet different conditions.

The following chart shows the variation in the acceptable periods of reverberation for auditoriums of different volumes and different conditions of use. The values are taken from the work of a number of investigators. It will be obvious that the period of reverberation of an auditorium will always vary over a considerable range of values as the audience size changes. The values given on the chart are designed to adjust the reverberation to average audience size so that it will not be too high when the room is nearly empty, and not too dead when it is fully occupied. It is probable that a variation of as much as five or ten per cent can be permitted in the calculations without resulting in any pronounced change in the acoustics of the room.

CHART SHOWING ACCEPTABLE PERIOD OF REVERBERATION FOR DIFFERENT TYPES OF AUDITORIUMS

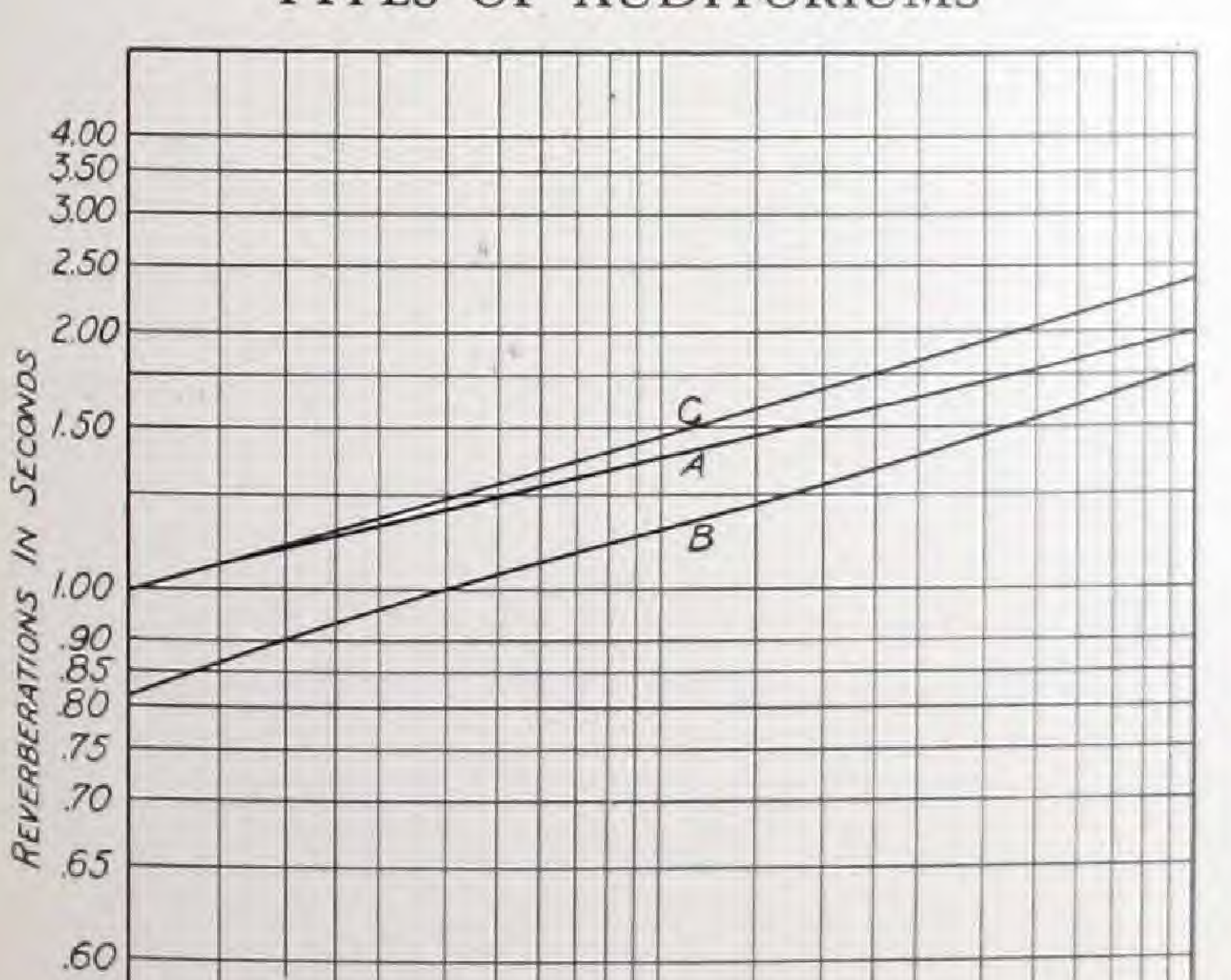


CHART No. 2

A=*Average Audience. General Auditorium Correction.*
B=*Average Audience. Sound Film Theatres.*
C=*Average Audience. Music and Concert Halls.*

SUGGESTED ABSORPTION FREQUENCY CURVES

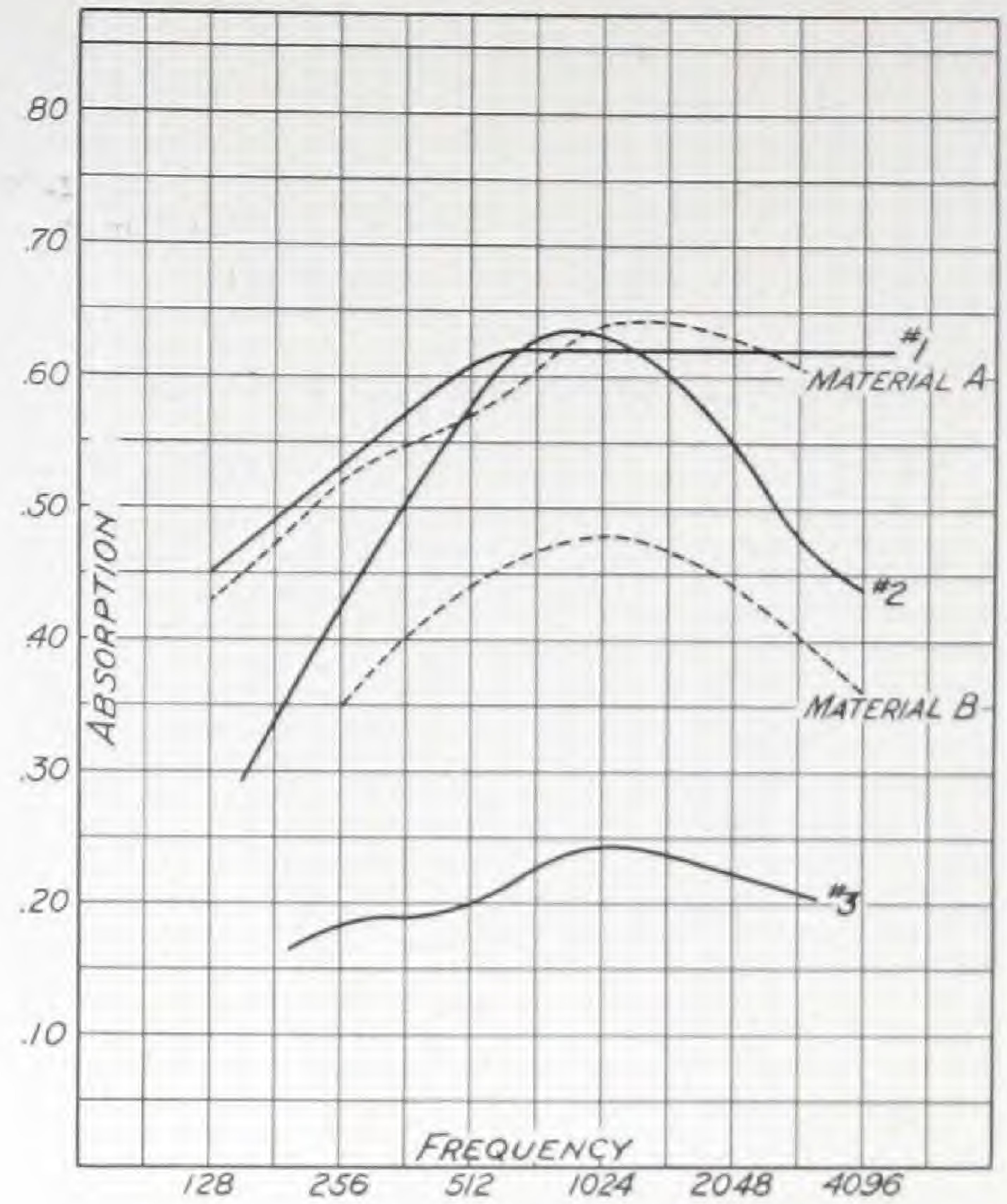


CHART No. 3

Curve No. 1 — Ideal Absorption based on frequency-sensitivity of ear.
Curve No. 2 — Ideal Absorption based on frequency-distribution of piano selection.
Curve No. 3 — Ideal Absorption based on normal room absorption.
Material A — Johns-Manville 4" Rock Wool Treatment.
Material B—Johns-Manville Nashkote A-I-S (7/8").

Similarly a variation of a few percent in the absorption of the material used to correct the reverberation does not introduce any serious error into the calculations. Differences of more than a few percent must be considered, however, especially as larger areas of treatment are considered.

In using the figures given in Chart No. 2 for ideal reverberation conditions it is necessary to use the standard Sabine formula t=.05V/as or the modified form $t=\frac{.0083V}{as}(9.1-\log a)$, if the error introduced is considerable.

The above charts were based on auditoriums generally accepted as satisfactory and the periods given for these auditoriums were in almost all cases calculated either from plans or from measurements in the empty room using these formulae. As has been pointed out it is neither correct nor desirable to substitute the figures given for varying sound sources (Table I) in these calculations. These figures are to be applied only in checking actual experimental measurements.

Variations with frequencies

Up to this point it has been tacitly assumed (except in the discussion of humidity effects) that all calculations and coefficients are for a frequency of 512 cycles. This, however, is merely a general average pitch, and in certain cases it becomes important to extend the absorption calculations for the entire frequency range. Several methods of determining the ideal absorption frequency characteristics of the corrective material have been suggested.

Chart No. 3 shows the general shape of the resulting curves applied to rooms having volumes varying from 64,000 to 100,000 cu. ft. Curve No. 1 is derived from values developed by E. F. MacNair of the Bell Telephone Laboratories, predicated on the assumption that the rate of decay of sound in a room should follow the ear sensitivity curve for various frequencies. Curve No. 2 is the absorption frequency characteristic of a material which would give uniform periods of reverberation at all frequencies for a typical piano selection. (We are indebted to Dr. Sivian of the Bell Telephone Laboratories for the information on power distribution and to Dr. V. O. Knudsen for the method of presentation.)

Curve No. 3 shows the average absorption coefficient for all surfaces of a typical room seating about 700 persons with acoustical conditions normally considered. The seats have upholstered backs. The coefficients allowed for seats and audience are those recently published by the Bureau of Standards. This curve is shown because certain engineers have contended that sound quality, particularly that of music, is judged entirely by past experience and habit—hence the frequency characteristic of a treated room should as nearly as possible conform to satisfactory untreated rooms already in existence.

After such a study has been made it becomes of practical interest to discover what materials are available having the desired characteristics. Two Johns-Manville materials which very closely approximate the requirement are given.

Instruments and technique

The developments which have taken place in acoustical science are largely due to improved instruments and testing technique. It may be of interest to mention these briefly, since it has been the policy of Johns-Manville in all cases to make such methods and apparatus part of its engineering service.

Electrical apparatus has been developed which will measure and record sound intensities at any desired point. With such apparatus the sound distribution in an auditorium may be determined. Combined with a set of electrical or mechanical filters, it is possible to extend this analysis to each part of the frequency range. This equipment has likewise been adapted in various ways to measure the period of reverberation, or the rate of sound decay in any part of the room. This technique has obvious advantages over methods which depend upon the ear, and an uncalibrated source.

It is possible to set up small-scale models of an auditorium and study echoes and possible sound concentrations. A picture made from the floor plan of the Howard Theatre mentioned in the early part of this book of one such model is shown. Note the points of sound concentration. This method of analysis is in some ways superior to tests which depend on data obtained in the completed room, not only because less apparatus is required, but also because the engineer is enabled to make definite predictions in advance of construction.

In certain cases where instrumental methods have not been suitable, a type of experiment known as an "articulation" test has proved very useful. These tests give the most direct criterion of the acoustical quality of the room, since they depend on the actual degree of sound intelligibility in the room. A "caller" speaks a selection of so-called "meaningless" words (deliberately meaningless in order to avoid possible association of familiar sounds in the mind of the listener), and various observers write down what they hear as they sit in different parts of the room. The percentage of words recorded correctly is called the "percentage of articulation," and experience with a crew of trained observers soon shows what this value should be if the room is to be adjudged satisfactory.

A discussion such as this is at best superficial, and we can do no more than indicate briefly the tremendous scope of acoustic research. However, the Johns-Manville Engineering Department makes it a part of their work to collect and make available all such data, and the owner, architect or builder, has only to call on them to have this information at his disposal.

The acoustically correct chapel in the Cincinnati Children's Hospital, Cincinnati, Ohio. Special hand mottled effects and plaster were cemented to the surface of the J-M Nashkote, which was used here as the sound absorbing material to provide good acoustics under all degrees of attendance
Architects—Elzner & Anderson; Associate Architect—Stanley Matthews

A *complete* acoustical service for every type of sound problem

BESIDES the problems of Acoustical correction which have been discussed in the pages of this book, there are also the problems of Sound Quieting and those of Sound Isolation.

The problem of noise has grown to be a big one. It has become a chief offender against the very efficiency of the age which brought it, and it affects our health and our work, hinders the recovery of our sick and even retards the mental and physical development of our children. These problems are encountered in banks, schools, offices, hospitals, stores, restaurants, hotels, clubs, and other places where we gather to work, eat, study, play or worship. This phase of sound control is discussed in a new brochure entitled "Solving the Growing Problem of Noise."

Problems of Sound Isolation are concerned with the transmission of sound through walls, floors, ceilings and other partitions. This type of problem also includes the isolation of sounds and vibrations caused by the operation of mechanical equipment in buildings of various types. The problems in this group differ from those of Sound Quieting or Acoustical Correction and require different methods of treatment.

Through a complete acoustical service, Johns-Manville is prepared to solve any problem of sound control which falls into any of these groups.

This service, which is based upon twenty years of practical experience and untiring research, includes more than the proper materials and their correct application. It includes complete analyses of acoustical conditions in auditoriums and buildings of all types, with specific recommendations for each particular problem —an engineering service which is at the disposal of any one interested in the control of sound.

Johns-Manville Acoustical Service is available in all major cities

J-M Acoustical Engineers are located in all the principal cities in the United States and Canada. They are at your service for consultation purposes.

In the larger cities you will find Approved J-M Acoustical Contractors, who are experienced, thoroughly familiar with all types of sound control work. They are qualified not only to make recommendations, but to prepare specifications and handle all work connected with the actual installation of Johns-Manville Sound-Absorbing Materials.

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Johns-Manville

Executive Offices: 292 MADISON AVENUE, NEW YORK
Cable Address: "JOHNMANVIL," NEW YORK

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